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THE TEKTITE II HUMAN BEHAVIOR PROGRAM

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Technical Report No. 14

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THE TEKTITE II HUMAN BEHAVIOR PROGRAM

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I. Introduction

The TEKTITE II Human Behavior Program was a large-scale, field investigation of ongoing human behavior in an isolated, confined environment. The program sought to advance basic research on individual and group behavior, to provide information useful for selecting crews and manning future underwater habitats, and to obtain data applicable to problems of long duration space flight.

The multiple goals of the research necessitated a broad approach to the collection of data with defined subareas of interest. A primary concern was the development of batteries based on pre-mission testing which can effectively predict performance and behavior in this and other settings. The research strategy was to attempt to refine general measures which can be validated against objective criteria and should have many applications in selecting personnel for a variety of tasks. Another major goal was to describe and explain patterns of adjustment to isolated and stressful environments. Directly related to this was the specification of trends in behavior over time and the comparison of these trends in missions of different lengths. This aspect of the study also included determination of the intercorrelations between such components of behavior as work, leisure, sleep and communication. Also of primary interest was the study of crew composition and its effects on performance. Components of this research area were leadership roles, scientist-engineer relations and the effects of partial crew rotation.

Secondary research goals encompassed detailed study of communications patterns, social dominance, utilization of space within the habitat, meal behavior, energy expenditure, mood fluctuations and territoriality.

Four modes of data collection were employed: (1) psychological testing prior to each mission; (2) continuous observation of in-habitat behavior by closed circuit television and open microphones; (3) self-reports on emotional state by Aquanauts; and (4) structured debriefing of each Aquanaut immediately after decompression. The systematic, quantified observation of in-habitat behavior was the heart of the program. Behavior was monitored 24 hours a day during the 182 days that the habitat was occupied by the ten scientific missions.

Methodological Significance of the Program. The TEKTITE research was conducted at a time when a serious division has arisen in American social psychology. The controversy is between those who advocate experimental, laboratory, social psychology and those who favor observational, naturalistic research in real-life situations. The points of contention have been extensively argued elsewhere (cf. Willems and Rausch, 1969; Aronson and Carlsmith, 1968; Radloff and Helmreich, 1968). Briefly, however, the laboratory exponents hold that only in a controlled, experimental situation can valid conclusions about causality be reached and that field research, by its correlational nature, can only describe relationships without defining causes. Field researchers contend that their findings can be more easily generalized to other real situations. They also argue that modern statistical techniques can provide much information about causal relations from correlational data and that field techniques may be the only ethical way to study some phenomena such as prolonged stress. Perhaps the only certainty is that the resolution (or partial resolution) of this conflict will influence the course of social psychology for some time.

The TEKTITE behavior program, as one of the largest systematic, field studies undertaken in social psychology, may be a significant source of data on the usefulness of field techniques. Accordingly, it may be of value to review briefly the development of the research design and to note some of the advantages and disadvantages associated with it.

Origins of the Behavior Program. The present study is a direct outgrowth of research conducted on Aquanauts during the Navy's SEALAB program (Radloff and Helmreich, 1968). The SEALAB research was undertaken because the investigators felt that the systematic observation of men under high stress in a situation where good criteria of performance were available could provide unexcelled data on individual and group reactions. A number of significant findings emerged from the SEALAB study which led to renewed interest in developing techniques for collecting and handling the large amounts of data obtainable. These techniques were tested during TEKTITE I and modified and refined for TEKTITE II.

There are numerous advantages of an underwater habitat as a naturalistic research setting:

1. The research situation is completely real. Stress, isolation and confinement are not simulated. Accordingly, reactions to the pressures of the situation are valid measures of behavior. Related to this is the fact that research subjects are participating to fulfill professional goals and not merely to serve as psychological guinea pigs. Thus, the goal of the subject is primarily to get his work done and not to serve as a cooperative and obedient psychological subject.

2. The habitat provides a relatively stable and constant environment. Unlike many field situations, all subjects could be observed under the same living conditions. This enables statistical comparison across individuals and across teams.

3. The design of the habitat provides excellent audio and video coverage. Observers could monitor almost all in-habitat activity.

4. An extensive battery of psychological data could be obtained on each Aquanaut prior to his mission--an unusual situation in field research.

5. The natural situation provided excellent objective criteria of performance and adjustment. These variables form the criteria for prediction of individual reactions and the study of trends in behavior over time. Between four and six thousand observations (depending on mission length) were taken on each of the criterion variables on each Aquanaut.

Offsetting some of the desirable characteristics noted above are several disadvantages. The number of subjects (48) and missions (10) is relatively small. A larger sample with more replications would give broader and more stable data.

The TEKTITE habitat was fairly shallow and was located in warm, clear water; as a result, the stress levels were less extreme than those found in projects such as SEALAB II and III. The shallow depth also made it more difficult to maintain isolation. A larger sample of female Aquanauts and mixed crews would have enabled better evaluation of the obtained results. Only additional research will show how well the findings based on this sample of volunteer scientists and engineers will generalize to other situations and populations.

Overall, however, the advantages clearly seem to outweigh the limitations of such research and the methodology developed should be applicable to many settings.

Scope of the Report. Time and space limitations make it impossible to present more than a fraction of the data in this report. The concentrations here will be on a general description of some of the major findings. The areas to be emphasized will be (1) overall behavior in the habitat, (2) team and individual differences in reactions, (3) trends in behavior over time, (4) crew composition and (5) prediction of behavior.

Topics for Subsequent Analysis. It may be useful to list here aspects of the data which will be the subject of later analyses and will be reported in more detailed technical reports. These include:

1. Habitat utilization.
2. Territorial behavior.
3. Diving behavior.
4. Meal behavior.
5. Communications (including within-habitat and habitat-to-surface communication).
6. Content analysis of video tapes.
7. Mood data.
8. Analysis of diurnal cycles.
9. Effect of external and internal perturbations (storms, illness, etc.) on behavior.
10. Sociometric evaluations.
11. Rod and Frame Test.
12. Self-esteem data.
13. Social dominance.
14. Gregariousness.
15. Detailed analysis of leisure activities.
16. Comparisons with data from other isolated environments.

II. Methodology

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Data collection was conducted in four ways: (1) pre-mission testing; (2) continuous observation of in-habitat behavior; (3) self-report questionnaires filled out daily by Aquanauts during their dive; and (4) structured debriefing of Aquanauts immediately after decompression.

Pre-Mission Testing. After arrival at the base camp, each Aquanaut was given a complete briefing on the scope and goals of the Behavior Program. The nature of data to be collected and provisions to ensure the confidentiality of all responses were explained. Following the briefing, each Aquanaut completed a battery of demographic and personality measures. These measures are listed in Table II-1. The major pre-mission measure was the Life History Questionnaire. Its theoretical importance is such that it is described in detail in Section III. Variables from these instruments are used both to describe the Aquanaut population and to predict performance and adjustment during missions.

Behavioral Observations During Missions. The major source of data during TEKTITE II was the direct observation of Aquanauts 24 hours a day during their life in the underwater habitat. These data were collected by three teams of male observers from the University of Texas at Austin. Each team served on-site for approximately 2 1/2 months. Team 1 had eight observers; Team 2, ten (augmented to collect data on the aborted Minitat missions); and Team 3, eight. Observers were undergraduate or graduate students at the University of Texas who were trained in systematic observational techniques. They were also qualified divers who provided logistic diving support for each Aquanaut team while it was living in the habitat. This common interest in diving and Aquanaut support served to build rapport between the psychological mission and the Aquanauts.

The variables on which data was collected were developed and defined from research programs conducted during SEALAB II & III and TEKTITE I (see Radloff and Helmreich, 1968 and Radloff, 1969 for further exposition of the research design). The final definition of variables was determined by the authors in conjunction with Richard S. Mach of Bellcomm, Inc. and Roland Radloff of the Naval Medical Research Institute.

Relevant categories of in-habitat behavior were specified and explicitly defined in a Behavior Observer's Manual which each observer was required to master.* The manual contains an introduction to the observer role, a description of each behavioral measure and its mode of collection, and a description of the habitat. Considerations of confidentiality and the operation of the IBM Information Recorder which was used for data collection are also included.

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*A copy of the Behavior Observer's Manual can be obtained on request from Robert Helmreich. It will be published later as an Office of Naval Research Technical Report.

Table II-1
Pre-Mission Measures

I. Specially Developed Tests

*A. Aquanaut Background Questionnaire

Variables

1. Current occupation.
2. Age.
3. Sex.
4. Highest grade level attained.
5. Current participation in organized religion.
6. Parents' current status (deceased, divorced, etc.).
7. Number of brothers.
8. Number of sisters.
9. Birth order.
10. Adopted or not.
11. Family mobility (number of moves).
12. Father's education.
13. Mother's education.
14. Father's occupation.
15. Military service.
16. Smoking habits.

*B. Life History Questionnaire

Items	Age Range (by year)
1. Geographical residence.	0-18
2. Hometown size.	0-18
3. Distance of home from larger population centers.	0-18
4. Type of residence.	0-18
5. Condition and status of residence.	0-18
6. Family size and composition.	0-18
7. Clothing quality.	0-18
8. Food--quantity and quality.	0-18
9. Father's employment.	0-18
10. Mother's employment.	0-18
11. Height.	0-18
12. Weight.	0-18
13. Health.	0-18
14. Education--type of school.	5-18
15. Education--size of school.	5-18
16. Education--academic performance.	5-18
17. Athletic achievement and awards.	5-18
18. Intellectual achievement and awards.	5-18
19. Other awards and honors.	5-18
20. Religious activities.	5-18
21. Going out at night.	5-18
22. Dating.	12-18
23. Fights with peers.	5-18
24. Clashes with authority.	5-18
25. Financial independence.	5-18

Table II-1
page 2

Items	Age Range (by year)
26. Work--school year.	5-18
27. Work--summer months.	5-18
28. Parental praise.	5-18
29. Parental physical affection.	5-18
30. Parental verbal criticism.	5-18
31. Parental physical punishment.	5-18
32. Community homogeneity and personal similarity.	0-18

C. Texas Social Behavior Inventory

A measure of general social competence based on 40 multiple choice questions.

D. Swimming Questionnaire

48 items related to swimming experience.

E. Prior Acquaintance Questionnaire

Assessment of familiarity with members of own and other missions.
1. Professional acquaintance.
2. Social acquaintance.

II. Standard Tests

*A. Allport-Vernon-Lindzey Study of Values

Derived scales.
1. Theoretical values.
2. Economic values.
3. Aesthetic values.
4. Social values.
5. Political values.
6. Religious values.

B. Minnesota Multiphasic Personality Inventory

(Standard personality test administered prior to selection, but not used in selection.)

**C. 16-PF-Test

*Indicates that variable or measure is discussed in this report.
**Only the IQ score derived from this test is used.

Video training tapes were made inside the habitat before it was shipped to the Virgin Islands and were used to refine observational measures and to train observers under realistic conditions of simulated observation. The second and third teams of observers also received on-the-job refresher training by standing watches on-site for a week with the observers they replaced.

Behavioral observation was conducted in a restricted area of the Command Van located on shore. The behavioral area was equipped with six 18" TV monitors--one showing each compartment of the habitat, one showing a TV picture in the water outside the habitat and one reserve unit. Three video tape recorders were also installed enabling instantaneous recording of any signal received on the TV monitors. Two playback monitors for display of video tape were installed.

Three loudspeakers and two headphone jacks were installed with two switching controls permitting observers to monitor conversations in any area of the habitat.

Data were collected twenty-four hours a day by observers standing watch in pairs for four hour shifts. Observers were instructed not to discuss behavior observed with anyone other than supervising personnel, and access to the observation area was strictly limited. Persons not associated with the Behavioral Program were permitted in the observation area only with the consent of the Aquanauts.

Most data were collected by being punched directly onto IBM cards using the IBM Model 3000-I or Model 3000-II Information Recorder. Separate recorders were prepared with guide templates for recording Aquanaut status, dive behavior, meal behavior, arising-retiring and sleep duration, communications with topside and specific events such as use of leisure facilities, housekeeping, baralyne changes, etc. An example of an Information recorder Template (for Aquanaut Status Record) is shown in Figure II-1. The Aquanaut Status Record was completed for each Aquanaut every six minutes, 24 hours a day. Other records were punched whenever the event in question occurred. A summary and description of the variables collected by observation is presented in Table II-2.

In addition to punching data on cards, observers maintained a log with entries concerning any unusual events occurring in the habitat or at the dive site.

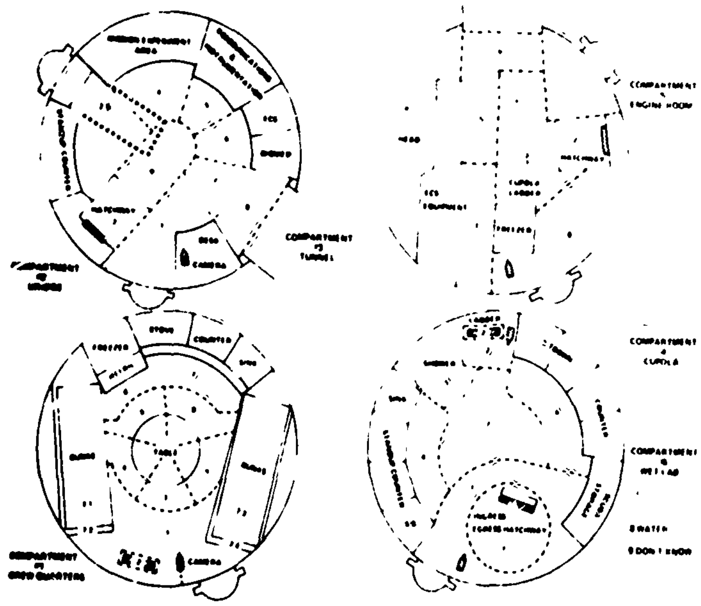
Video tape recordings of habitat behavior were also made. Systematic samples of group interactions with all Aquanauts present were taken and emergencies, interpersonal disputes and other events judged significant by observers were recorded. The tapes will later be subjected to content analyses by trained judges.

<u>Self-Report Data</u>. Each Aquanaut was asked to fill out a mood adjective checklist twice a day. The mood checklist taps areas of emotionality such as fear, arousal, well-being, depression, etc. Although less than 100% cooperation in filling out these forms was obtained, the data promise to offer much information on individual perceptions of the environment and their relations to performance and adjustment. These results will be reported in a subsequent technical report.

<u>Post-Mission De-Briefing</u>. As soon as medical examinations permitted, each Aquanaut was debriefed alone by the principal investigator and/or supervisor of the Behavior Program (Helmreich and/or LeFan) and a representative of the Habitability Program. The interviews were tape recorded and covered a wide range of topics including reactions to the habitat, interpersonal relations, achievement, physiological changes and other concerns. Much useful information was derived from

Figure II-1

AQUANAUT STATUS RECORD



ACTIVITY CATEGORIES	COMMUNICATION CATEGORIES	POSTURE CATEGORIES	MOVEMENT CATEGORIES
11 DIRECT MARINE SCIENCE		11 STANDING-ERECT	
0 MAR SCIENCE SUPPORT		0 STANDING-SLOUCHING	0 NO MOVEMENT
1 LOCOMOTING	1 NOT COMMUNICATING NEITHER TALKING NOR LISTENING	1 STANDING-LEANING	1 LIGHT TRANSLATIONAL
2 HABITAT MAINTNC AND REPAIR	2 TALKING WITH ANOTHER AQUANAUT	2 SITTING-FORWARD	2 MODERATE TRANSLATIONAL
3 SELF MAINTENANCE	3 LISTENING TO AQUANAUT #1	3 SITTING-UPRIGHT	3 VIGOROUS TRANSLATIONAL
4 MAINTENANCE OF OTHERS	4 LISTENING TO #2	4 SITTING-SLOUCHING	4 LIGHT MANIPULATIVE
5 CO RECREATION	5 LISTENING TO #3	5 RECLINING	5 MODERATE MANIPULATIVE
6 SOLITARY RECREATION	6 LISTENING TO #4	6 SQUATTING	6 VIGOROUS MANIPULATIVE
7 RELAXING RESTING IDLING	7 LISTENING TO #5	7 KNEELING	7 LIGHT EXPRESSIVE
8 NAPPING SLEEPING	8 TALKING OR LISTENING TO TOPSIDE	8 ALL FOURS	8 MODERATE EXPRESSIVE
9 DON'T KNOW		9 LYING DOWN	9 VIGOROUS EXPRESSIVE

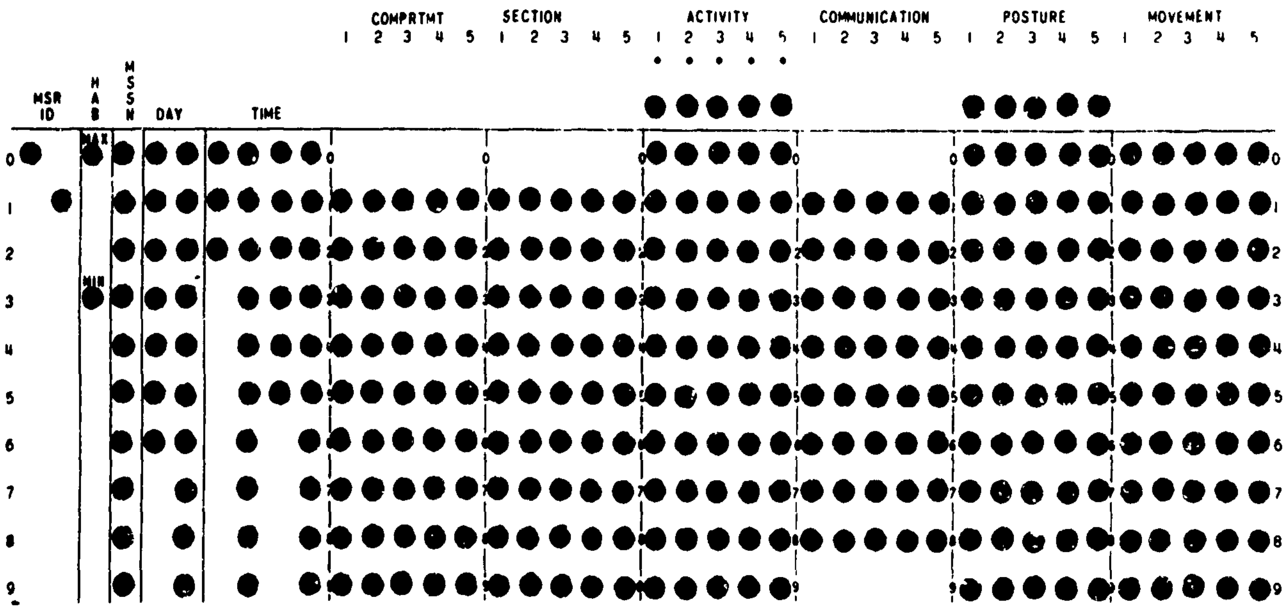


Table II-2
Measures Collected by Observation During Missions

IBM Portapunch Template

I. Aquanaut Status Record

Variable	Frequency or Time of Collection
A. Location by compartment and section of each Aquanaut.	Every 6 minutes
*B. Activity of each Aquanaut.	Every 6 minutes

Categories of activity
1. Direct marine science.
2. Marine science support.
3. Locomoting.
4. Habitat maintenance and repair.
5. Self-maintenance.
6. Maintenance of others.
7. Co-recreation.
8. Solitary recreation.
9. Relaxing, resting, idling.
10. Napping, sleeping.

Composite variables composed by grouping activity categories for summary data
1. Total Work--sum of time spent on Direct Marine Science, Marine Science Support, Habitat Maintenance and Maintenance of others.
2. Total Marine Science--sum of time spent on Direct Marine Science and Marine Science Support.
3. Total Leisure--sum of time spent in co-recreation, solitary recreaction and resting, relaxing, idli o.

*C. Communication of each Aquanaut	Every 6 minutes

Categories
1. Not communicating.
2. Speaking to another Aquanaut.
3. Listening to Aquanaut #1.
4. Listening to Aquanaut #2.
5. Listening to Aquanaut #3.
6. Listening to Aquanaut #4.
7. Listening to Aquanaut #5.
8. Communicating with surface.

D. Posture of each Aquanaut	Every 6 minutes

Categories
1. Standing erect.
2. Standing slouching.
3. Standing leaning.
4. Sitting forward.
5. Sitting upright.
6. Sitting slouching.
7. Reclining.
8. Squatting.
9. Kneeling.
10. All-fours.
11. Lying-down.

*Measures discussed in this report.

Variable	Frequency or Time of Collection
E. Movement of each Aquanaut.	Every 6 minutes
Categories	
0. No movement.	
1. Light translational movement.	
2. Moderate translational movement.	
3. Vigorous translational movement.	
4. Light manipulative movement.	
5. Moderate manipulative movement.	
6. Vigorous manipulative movement.	
7. Light expressive movement.	
8. Moderate expressive movement.	
9. Vigorous expressive movement.	

II. Dive Record

Variable	
A. Dive start time.	Each occurrence
B. Equipment used.	" "
C. Order of egress.	" "
D. Dive duration.	" "
E. Ingress order.	" "

III. Meal Record

Variable	
A. Start of meal.	Each occurrence
B. Primary cook.	" "
C. Waiter.	" "
D. Duration of meal.	" "
E. Primary clean-up diver.	

IV. Arising-Retiring Record

Variable	
A. Time of arising.	Each occurrence
B. Time of retiring.	" "
C. Duration of time asleep.	" "
	" "

V. Specific Events Record

Variable	
A. Maintenance of habitat by each Aquanaut	Each occurrence
Categories	
1. Housekeeping.	
2. Habitat maintenance.	
3. Habitat repair.	
4. Baralyme change.	

Variable	Frequency or Time of Collection
B. Maintenance of self or other by each Aquanaut	Each occurrence
Categories	
1. Head usage.	
2. Use of shower.	
3. Laundry.	
4. Handling of food.	
C. Use of Facilities by each Aquanaut.	Each occurrence
Categories	
1. Watching outside TV.	
2. Watching TV type for entertainment.	
3. Watching TV tape for training.	
4. Listening to radio.	
5. Using general leisure package.	
6. Using items from personal leisure package.	
7. Use of pressure pot.	
8. Use of winch.	

VI. Communication with Topside Record

Variable	
A. Initiator of communication	Each occurrence
Categories	
1. Topside.	
2. Aquanaut.	
B. Device used	Each occurrence
Categories	
1. Open microphone.	
2. Intercom.	
3. Telephone.	
4. Videophone.	
C. Duration of conversation	Each occurrence
D. Content of communication	Each occurrence
Categories	
1. Operational	
2. Social	

these interviews. However, difficulties in transcription make it necessary to defer results of this portion of the study to subsequent technical reports.

Although no systematic data from debriefing will be presented in this report, one finding consistent with earlier research should be noted here. This is that self-reports of performance elicited after an experience are not valid indices of the actual behavior exhibited. Frequently, those Aquanauts expressing most pride in their achievements rated among the lower performers, while those expressing personal dissatisfaction with personal performance were high on objective indices of performance. Radloff and Helmreich (1968) have discussed problems with self-report in detail. The present body of data may offer a chance to analyze the systematic distortions present in self-evaluation of behavior.

Following the interview, each Aquanaut was asked to fill out a sociometric questionnaire nominating those Aquanauts he would most like as team-mates on a subsequent saturation dive and those he would most like as team leader.

Summary. As noted, the bulk of the research effort was directed at collecting complete quantitative data on personal and interpersonal activities during the total stay underwater. The variables observed can be used to form criterion variables or factors for the prediction of behavior and can also be used for analyses of trends in behavior over time and the study of interrelations of discrete behaviors. The pre- and post-dive measures provide variables to correlate with the highly detailed objective data available on each Aquanaut's reactions to the undersea environment.

III. The Life History Questionnaire
A. Background and Design

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The majority of the data used in predicting performance and adjustment in TEKTITE II comes from the Life History Questionnaire (LHQ). This section contains a brief account of the theoretical argument for the use of life history information and a description of the development and major features of the LHQ.

Rationale for Use of Life History. One of the most widely accepted truisms in psychology is that, "The best predictor of future behavior is past behavior." Research evidence supports this; for example, the best predictor of college grades is high school grades; previous income predicts success in selling life insurance (Tanofsky et al., 1969); completion of high school predicts completion of service school and Navy enlistment (Plag and Goffman, 1966); it is assumed that the best jet pilots will be the best astronauts (Voas, 1961). These simple examples provide basic support for the use of life history information in prediction.

Our own previous research has also convinced us of the value of such information. Life history items were very successful in predicting performance in SEALAB II, especially in contrast with personality and interest inventory data. (See Radloff and Helmreich, 1968). At a more general level, theoreticians have argued the potential power of life history information. (See Guthrie, 1944, for an especially compelling argument.) Finally, a recent conference of experienced users of biographical information asserted that it is, "The best single predictor of future behavior where the predicted behavior is of a total or complex nature." (Henry, 1966). Thus, there appears to be compelling arguments for the use of life history information. The general proposition is straightforward, well accepted and documented. However, it proved to be deceptively simple in its application to the research goals of project TEKTITE.

In TEKTITE, we were attempting to predict complex criteria of performance and adjustment. Our goal was to understand and explain differences among TEKTITE participants in their ability to work well, get along with fellow team members, and to adjust generally to their environment. Since we were attempting to predict complex real-life behavior, it followed that the best predictive information would be a total record of prior experiences. We looked for and failed to find extant measuring instruments which would yield such information.

The Undeveloped Potential of Life History. Despite the widely assumed and partially demonstrated utility of life history information, very little effort has been devoted to understanding the conceptual properties underlying such information. It appears that biographic data have been used because they work. They have been used mainly in practical, applied situations such as counselling and personnel selection and on a strictly empirical level. The truism regarding past behavior may appear so self-evident that it precludes the question "Why does it predict?" In any case, users seem to have had little inclination to develop conceptual and theoretical understanding of the information. (Cf. Baehr and Williams, 1967.) The norm seems to have been that each investigator has used a few life history questions either because they had been used previously or because there was some "common sense" notion that they would have relevance to his study. Whether in field or laboratory studies, applied or basic research, only a few variables have been used in most studies. This has resulted in the investigation of a large number of variables and conceptual understanding of almost none. Examples of standard items are: age, education, parents' education, occupation, income, socio-economic status, hometown size, educational performance, age at graduation from school, running away from home, religious affiliation and participation, family stability, and birth order.

Recent investigations of birth order illustrate one of the deficiencies in the use of life history information. Since the publication of Schachter's Psychology of Affiliation (1959), hundreds of investigators have examined birth order in the laboratory and in the field, in relation to a variety of criteria. However, despite this massive research activity there is little understanding of the psychological properties of the variable. We agree with Sampson (1965) that a large part of the difficulty is that birth order has been studied in isolation from other relevant information. In order to identify (accurately) its effects and to understand them, it is necessary to study birth order in relation to a large number of other variables. A few of the more relevant ones would seem to be sex, family size and composition, and socio-economic status. A similar situation exists in regard to almost any life history item. Most have been studied in isolation. There is a need to study them in a comprehensive context.

A result of the lack of systematic attention to life history information is the absence of standard measuring instruments. The "bible" of tests, Buros' Mental Measurement Yearbook (1965), lists only a few biographic or life history forms. These forms are largely interviews which yield qualitative data appropriate for use by counsellors or personnel managers. They have not been reviewed or studied. Buros does not include any reviews of life history questionnaires and notes that no reliability and validity information is available for any of the forms listed. There were no references for any of the life history forms. In striking contrast is the status of personality tests. Buros lists 196 personality tests, 125 of which are reviewed. Reliability and validity data are given for the majority. One test, the Minnesota Multiphasic Personality Inventory, had a bibliography of nearly 1400 references by 1964. Convinced of the utility of comprehensive life history information and finding no suitable measuring instruments available, we decided to develop our own omnibus life history questionnaire.

Design of the Life History Questionnaire. The Life History Questionnaire was conceived and designed to assess experience and behavior during the first 19 years of a person's life. Its intent is to elicit relatively comprehensive information. To this end, a large number of questions are asked. Major areas covered are: place of residence, size of hometown, frequency of moves, type of residence (single family, etc.), size of residence, family size and composition, quality of food and clothing, father's and mother's employment, education and occupation, comparative height and weight, health, type and size of school, school performance, participation in athletic and other activities, religious participation, frequency of going out at night and dating, fights with peers, clashes with authority, parental praise, criticism, physical affection and punishment, work, and financial independence. These are shown in Table II-2.

Comprehensive coverage is of course a matter of degree. The potential number of questions which could be asked is enormous. The most comprehensive form we have found is a 130 page "Psychiatric History Form." The goal of our questionnaire is to tap important areas of life history. Several sources were consulted in deciding on the areas to be covered. These sources range from biographies and the child development literature to an examination of specific questions on existing instruments. Two major influences guiding the selection of areas to be covered were: A Catalog of Life History Items (Owens, et al., 1966) and a factor analysic study of the dimensions of personal background data (Baehr and Williams, 1967).

Eliciting factual information is not as simple as it might seem. There appears to be confusion in the field over what constitutes a fact of life history. For example, a majority of the questions appearing in the Catalog of Life History Items do not ask for factual information. Instead, they deal with attitudes, feelings, and opinions, for example: "How do you feel about your share of happiness in life?"; "What type of person do you like?". Opinions, attitudes, and feelings deserve to be studied in their own right, as indeed they have been. However, they should not be confused with facts about past experience.

Questions in the LHQ emphasize the occurrence of events rather than attitudes and feelings. For example, "In what size community did you live?" rather than, "In what size city would you prefer to live?"; or, "How often did your parents punish you?" rather than, "How strict do you feel your parents were?"

In addition to non-factual questions, qualitative responses also dilute factual information. Qualitative responses result when response categories such as, "never, seldom, frequently, often, or very often," are used. The problem is, of course, that one man's "frequently" is another's "seldom." Even if the person recalls the information accurately, he may still not answer accurately because of semantic confusion. In the LHQ, wherever possible, responses are coded in numerical frequencies such as: once per year, once per month, once per week, daily, etc. Accuracy of recall and reporting, of course, still remain as potential sources of error, but semantic confusion is minimized by using quantitative categories. In an attempt to achieve valid and uniform response sets, the meaning of various response categories is explained in detail in the question stems. Many question stems are 200 or 300 words in length. The rationale for this approach derives from interviewing experience in which we found that brief questions are frequently not understood, whereas more detailed explanations produce better answers and fewer "Don't Remember" responses.

An essential feature of the LHQ is the provision for year-by-year responses. Twelve questions are answered 19 times, once for each year. The other 20 questions ask for responses only for appropriate years, for example, as in questions on dating, school attendance and performance. The use of multiple responses permits measurement of several important aspects of life history, including: number of changes, direction of changes, rate of development, and age at occurrence of an event. A few illustrations may explain the importance of such information. Later behavior may be influenced as much by the number of moves or changes in hometown as it is by hometown size; as much by improvements or declines in school performance as it is by average performance; as much by the rate at which financial independence is achieved as it is by the fact of its achievement; and, as much by the age at which parents were divorced or died as it is by the fact of divorce or death. Influences deriving from such factors as the number and direction of changes, rate of development and age at occurrence of events cannot be known unless data are available. Questions answered year-by-year seem to be the most sensitive method of obtaining these data.

The decision to cover ages 0 through 18 is perhaps not novel, but it is an important feature of the LHQ. This age span was chosen because it is long enough to give a good picture of how a person has developed. The case for the importance of the formative years has been well made by psychodynamic writers and others. Also, for many samples which the present investigators intend to study, subjects will be close to their 19th birthdays. Thus, comparable information can be obtained on a complete sample using the 19th year as the stopping point. Finally, experiences tend to be more similar and more structured across groups and societies during childhood and adolescence making it easier to compare life patterns. Later experiences may be quite specifically related to particular criteria. For example, amount of marine science training was of interest in TEKTITE. Supplemental questions covering such specific later experiences can and should be added to the basic core of information from the LHQ.

The provision of relatively large numbers of response categories is another distinctive feature of the LHQ. Most questions have nine factual response categories plus a "Don't Remember." Nine-point scales permit the discrimination which may be necessary to differentiate among members of relatively homogeneous groups. For example, if good school performance is closely related to a criterion natural selection will most likely produce a group which is relatively high and homogeneous on school performance. (This was the case in TEKTITE, since many of the scientists were holders of M.A. or Ph.D. degrees.) If the measuring categories have only a limited range, they cannot make sufficiently fine distinctions so that the influence of the predictor can be measured.

No one feature of the LHQ is completely novel. However, the use of all of them in combination has produced an instrument which is new in concept and design and which should yield data with outstanding predictive and explanatory power. The Life History Questionnaire does not measure personality, achievement, interests, values, attitudes, abilities, or adjustment in the traditional manner. However, one of its strengths is that all these areas are tapped in a direct descriptive fashion, objectively, not subjectively. Persons are asked what happened, not what they wished had happened, or hope will happen. No doubt, varying degrees of success were achieved in plumbing different areas. The final choice of questions as well as the format of the questionnaire is somewhat arbitrary. Different questions could have been asked and in different ways. Choices were necessary, since it is impossible to ask everything in all ways. We have tried to present here a brief rationale for choices which were made. Out intent is to obtain data with the richness of clinical assessment through the use of objective measurement. Whether we have succeeded in preserving at least some of the strengths of both techniques is an empirical question. Proof of the approach will be its success in predicting and understanding human behavior in a variety of situations in competition and in conjunction with alternative techniques. The preliminary results given in Section VIII are extremely encouraging.

B. Life History Data Processing

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In their rawest form, data from the Life History Questionnaire consist of a 32 by 19 matrix for each individual. Theoretically, each of 32 questions has 19 possible answers, one for each of the subjects' first 19 years of life. But for some questions, like dating behavior, responses in the early years are of little interest. For all questions, no one summary statistic is generally meaningful. With certain questions, a mode makes sense; for others, like size of hometown, the number of changes may also be of interest. Further, in some instances, only responses for certain years may concern us, or we may want to compare responses to a given question for the subject's early years with his later years. Thus we have developed a computer program (LIHAN--Life History ANalyzer) which allows us to extract from the raw data of the Life History Questionnaire values of conceptual variables of interest.

First, conceptual variables must be defined. This is done by constructing a table, where each entry or line in the table describes a different conceptual variable. This table is punched on cards which are then read by the program; thus LIHAN is a "table-driven" program, with its attendant advantage of flexibility. For each conceptual variable, the user must indicate: (1) the statistic to be computed; (2) the LHQ question to be used; and (3) within that question, the years to be considered. Among the statistics which LIHAN computes are: mean, median, mode, change scores, and trend scores (the latter are scores indicating whether changes are more in one direction than another).

Thus, LIHAN allows for the definition of a variety of predictive variables derived conceptually from the LHQ. Values for these conceptual variables are computed, and then printed out for inspection and punched on cards for further processing, as illustrated elsewhere in this report. New conceptual variables can be defined and computed as interest and further analyses suggest.

IV. Data Management Procedures

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Two major types of data were collected in the Virgin Islands. Observational data were punched on-site by University of Texas behavior observers onto IBM portapunch cards. Other measures were collected before and during each mission on questionnaires and mailed to Austin or California for keypunching.

Each card punched was hand checked on-site for obvious errors; mistakes were often corrected before distance from the event made this impossible. Cards were airmailed to Bellcomm, Inc. weekly. Bellcomm time-sequenced the cards, stored reformatted data on magnetic tape, and relayed to Texas the data as punched IBM cards, formatted printouts of the sequenced data, and card listings. At the University of Texas, data were screened by computer to eliminate any invalid data values and machine processing errors. Due to the large volume of data generated during each mission, four preliminary data reduction programs were written.* STATDAY gives daily totals on each variable for each diver from Status Record; MEALDAY, COMMDAY and DIVEDAY similarly combine data from the Meal Record, Communication Record, and Dive Record to give daily summaries. All data reduction programs compute values for either a complete day or for a whole mission and print and punch these summaries for inspection and further statistical analyses.

The major preliminary analyses to date have been on the Aquanaut Status Record using program STATREC. This program and several others were written before the project began to enable tabulation of Status Record data as missions progressed. All variables are totaled and converted to percentage scores to allow comparison across teams. From the various activity categories, composite criteria for total leisure, total marine science, and total work are computed. The utilization of each compartment and section of each compartment by each diver is calculated. Some communications analyses are also derived from Status Record; for example, talk/listen to topside, talk/listen to other aquanauts, and non-communication. A detailed gregariousness matrix is also computed consisting of the time spent by each diver talking to each of all possible groups formed from the other aquanauts.

The combination of variables recorded on the Aquanaut Status Record lends itself to easy calculation of location-specific activities. Territoriality scores for each diver in each section, and the sections most used by each team as a whole have been derived for leisure activities, for work activities, and for total activities.

Reduced Status Records have also been analyzed by special TEKTITE programs. Program DRAW provides labelled plotting of selected variables across time or missions for an individual diver or for groups. Program DEVIATE calculates for each diver a deviation score from the mean of the other four divers for any specified variable. These scores are punched for use in factor analyses, correlation, and regression analyses.

*A listing of any program mentioned in this report may be obtained on request from the authors.

Other measures collected by the behavior program arrived in questionnaire form. All have ben coded for identification and data format, and with the exception of the MACL's, have been keypunched at the University of Texas. The MACL's have been punched and forwarded to Texas by the Garret-Airesearch Corp., which is coordinating the habitability program. Analyzed data have been freely exchanged between these two research projects.

V. Characteristics of the Aquanauts

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The Aquanauts, as a group, formed a highly qualified and educated population. There were, however, large individual differences in experience and in personality characteristics. In this section, descriptive statistics from the Aquanaut Background Questionnaire and other pre-dive measures will be presented to provide an indication of the characteristics of the research group and to show the range of variation present. Predictive variables derived from the Life History Questionnaire are not included as they will be discussed in detail in Section VIII. Table V-1 shows data for Scientist-Aquanauts and Engineer-Aquanauts.

The most striking variability in scores is on age and diving experience. As can be seen in Table V-1, engineers had significantly less diving experience than scientist-aquanauts, although differences on most measures between scientists and engineers were not great. Overall, the Aquanauts came from generally middle-class or upper middle-class, stable families.

The two special teams (the Female Mission and the International Mission) did not differ significantly from other teams in background and personality variables. Forty-six of the Aquanauts were of Caucasian descent, one of Japanese-American origin and one of Chinese ancestry. Seven Aquanauts were born in foreign countries ranging from Europe to South America and the Orient.

A Note on the Allport-Vernon-Lindzey Study of Values. The Allport-Vernon-Lindzey Study of Values (Allport, Vernon and Lindzey, 1960) is a widely used test which measures the relative strength of six major value areas (theoretical, economic, aesthetic, social, political and religious). Norms have been developed for the general population and for specific occupations. (The population average is 40 on each scale.) The fact that the Scientist-Aquanauts score significantly higher on the theoretical scale than engineers agrees with special occupational norms. Of more interest is the fact that the profiles for TEKTITE scientists and SEALAB II civilian Aquanauts (Radloff and Helmreich, 1968) as well as Mt. Everest explorers (Lester, 1963) are almost identical. Scientists undertaking hazardous but professionally rewarding tasks seem to have a similar constellation of values characterized by high theoretical and aesthetic values, low religious values and average social, economic and political concerns.

Although teams do not differ significantly on background variables, recorded events during childhood and youth are significantly related to individual performance and adjustment underwater. These will be discussed in Section VIII.

Table V-1
Bacl.ground Characteristics of Aquanauts

	Scientists (N=40)	Engineers (N=8)
1. Mean Age	31.97	32.57
Range	25-42	22-45
2. Mean Years Scuba** Experience	9.82	3.86
3. Marital Status (Frequency)		
Single	4	3
Married	34	5
Divorced or Separated	2	0
4. Birth Order		
First born	22	4
Later born	18	4
5. Mean Number of Siblings	1.80	2.25
6. Number of Moves during Childhood	2.53	3.42
7. Father's Education (Frequency)		
Less than 8th Grade	0	1
8th or 9th Grade	5	0
10th or 11th Grade	4	0
H.S. Graduate	11	2
Some College	6	3
BA Degree	4	1
Advanced Degree	10	1
8. Mother's Education (Frequency)		
Less than 8th Grade	1	1
8th or 9th Grade	3	0
10th or 11th Grade	2	1
H.S. Graduate	17	0
Some College	8	5
BA Degree	4	1
Advanced Degree	5	0
9. Allport-Vernon-Lindzey Study of Values (AVL) Theoretical Score**	53.16	46.25
10. A-V-L Economic	37.03	40.75
11. A-V-L Aesthetic	45.18	40.38
12. A-V-L Social	37.08	36.00
13. A-V-L Political	39.24	41.25
14. A-V-L Religious	28.39	31.62
15. Intelligence (from 16.PF test)	8.61	8.50

** $p < .01$

VI. Patterns of Aquanaut Behavior

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This section describes overall patterns of behavior shown by the ten teams of Aquanauts. These data focus on the general patterns of observed behavior in the habitat and also on group differences in behavior across missions. The data are presented in several ways: (1) all ten missions are contrasted using percentage of total mission time spent on each activity as the basis for comparison. In these analyses, missions of different lengths as well as the female and international missions are treated equally; (2) missions of different durations are compared; (3) the reactions of the female crew are related to those of other crews; and (4) relations between scientists and engineers are discussed.

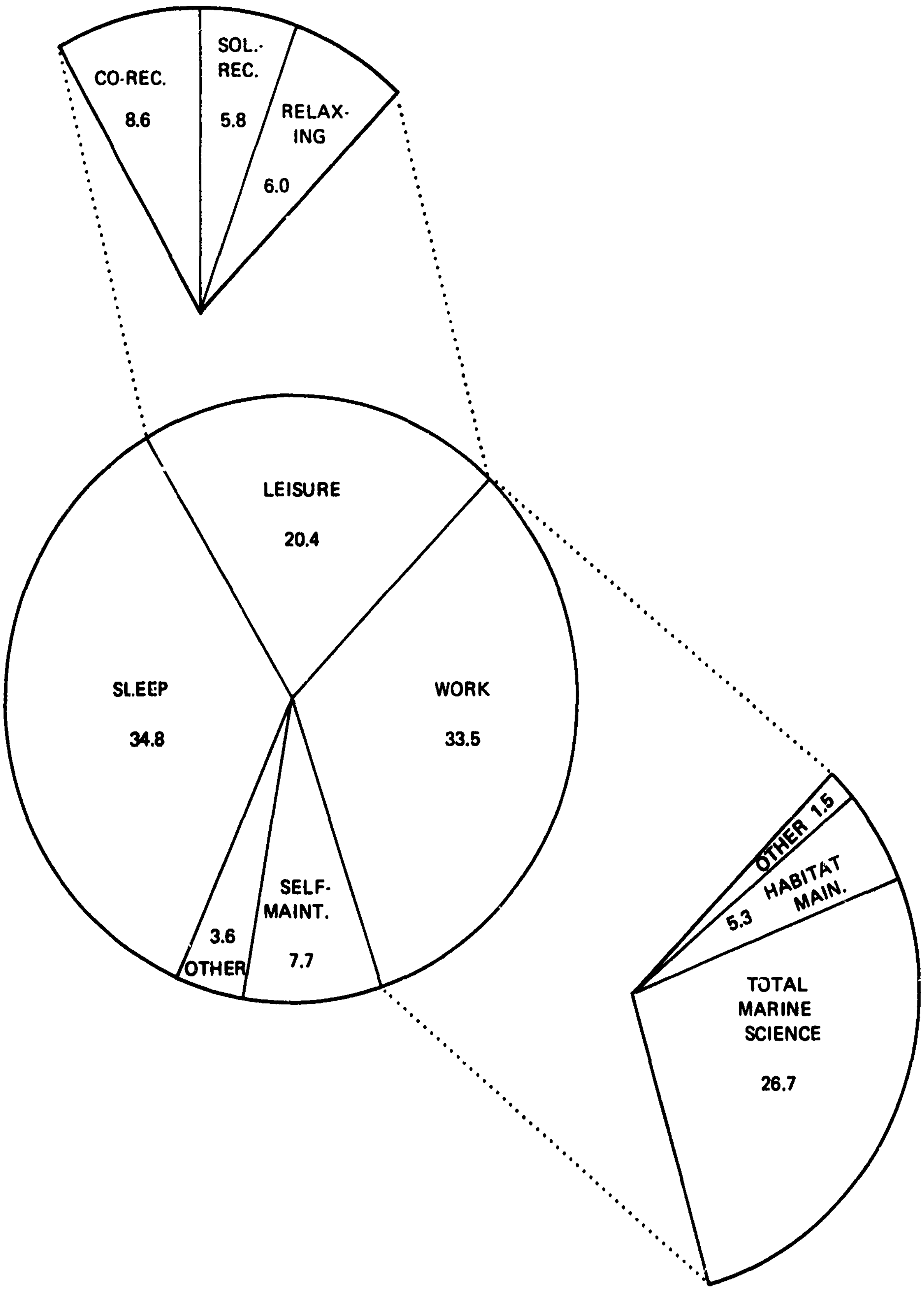
Two Important Notes. (1) As this is a preliminary analysis, data have not been adjusted to account for externally caused perturbations in Aquanaut behavior such as storms, equipment malfunction and illness. These factors will be included in later analyses; their function in the present treatment is to increase the error variance in comparisons and to reduce the significance of obtained results. Thus, this preliminary analysis provides the most rigorous test of the lawfulness of the observed behavior. (2) The stability and accuracy of the observational data should be emphasized. The variables that were recorded were objective and observers were highly trained. The reliability of the measures collected was assessed by having an independent observer recode the data from video tapes. His observations were then compared (by computing reliability coefficients) with those the observers made at the time the video tape was recorded. Across all variables, the correlations averaged between .89 and .97 indicating that the judgments of on-site observers were highly reliable and objective. This makes it possible to place great faith in the validity of behavioral indices. It should also be noted that reliabilities were highest on the more crucial criterion measures such as activity and location and were lower on secondary (and more difficult) judgments such as motion and posture. Another index of reliability was the number of times the "Don't Know" category was employed by observers (when they could not ascertain the location or activity of an Aquanaut). Less than 00.5% of the observations were in this category. Given that over 35,000 observations were made per subject, this speaks well of observer ability.

Team and Individual Identity. Because pre-mission testing involved many variables concerned with personal characteristics and because the Behavior Program monitored behavior continuously during the period spent in the habitat, special efforts have been made to preserve the anonymity of teams and Aquanauts. Each team has been assigned a letter code unrelated to mission designation and each Aquanaut a number designator within the team. Accordingly, references to teams or individuals do not systematically identify particular Aquanauts.

Overall Activity. The average percentage of total mission time spent on various activity categories by all Aquanauts is shown in Figure VI-1. As the figure indicates, Aquanauts spent a significant proportion of their time in productive endeavors. For all Aquanauts, the average amount of time spent working was 8.04 hours per day. Scientist-Aquanauts averaged 7.15 hours per day working on Marine

FIGURE VI-I

Mean Percentage of Total Mission Time Spent on Habitat Activities
(All Aquanauts)



Science. These mean times over several weeks represent far more undersea work than could have been achieved through operations from the surface. It is also obvious that the Aquanauts were primarily work-oriented during their sojourn on the bottom. Work and sleep combined accounted for the bulk of a day's activity with leisure pursuits playing a distinctly secondary role. The most prevalent leisure activity was the bull-session, typically during and after meals. Little time was spent on organized activities such as games and only occasional use was made of television tapes. Background music was widely used, but typically in conjunction with other activities.

There were large differences between teams on the variables composing the graph shown above. Table VI-1 shows the percentage of mission time spent on each activity for each team of Aquanauts. Components of composite criteria (Work, Leisure and Total Marine Science) are shown separately. The significant levels of the overall differences across teams were computed by analysis of variance and are shown in the table.

The range between the lowest and highest teams on many of the activity variables is striking. For example, Scientists on the highest team spent 39.4% of their time in Marine Science work (average 9.4 hours per day) while those on the lowest averaged 21.1% (average 5.1 hours per day). This represents an average difference of 4.3 hours per day. The team scoring highest on sleep spent 39.6% of its time sleeping (average 9.5 hours per day) in contrast with the lowest which spent only 30.8% (average 7.4 hours per day). This represents an average difference of 2.18 hours per day. Factors leading to team differences and the interrelations of activity variables will be discussed later. It should be noted that these figures represent <u>actual</u> time spent in the activities measured. An individual might spend 8 hours a day in an office but spend 30 minutes drinking coffee, 30 minutes in social conversation, 15 minutes relaxing, an hour eating, and the rest of the time working. In our system, he would be credited with 5.75 hours of work.

<u>Additional Comparisons of Missions</u>. The large differences found between individual missions raise questions as to whether these variations in behavior are a function of factors within individuals and social groups or whether they result from external factors such as mission duration. To evaluate these questions, analyses were performed to determine whether there were systematic differences between types of missions. These tested the proposition that differences between teams were a function of mission length. In these comparisons, results from the six twenty-day missions were combined and contrasted with results from the four two-week missions by unweighted means analysis of variance. The results are shown in Table VI-2.

As can be seen in Table VI-2, there were significant differences between long and short missions on several activity variables. These differences appear to be readily explainable as a function of circumstances related to mission duration and organization. Aquanauts on longer missions were more concerned with personal well-being. They spent significantly more time sleeping and in self-maintenance (personal hygiene, etc). This probably reflects a perceived need to keep oneself in top shape while working on a strenuous schedule.

Table VI-1
Percentage of Mission Time Spent in Activities by Team*

Variable	Mean% Miss. A	Mean% Miss. B	Mean% Miss. C	Mean% Miss. D	Mean% Miss. E	Mean% Miss. F	Mean% Miss. G	Mean% Miss. H	Mean% Miss. I	Mean% Miss. J	F-Ratio	Probability
1. Work	34.88	31.99	22.89	29.80	37.43	43.88	29.93	33.56	36.47	34.46	4.39	.0007
(a) Total Marine Science	29.53	26.01	18.52	24.59	31.33	35.63	23.02	26.31	27.80	24.08	1.50	N.S.
(1) Direct Marine Sciene	13.31	12.48	9.25	13.10	17.51	19.64	12.18	14.80	12.72	13.06	1.32	N.S.
(2) Marine Science Support	16.22	13.54	9.27	11.49	13.82	16.00	10.84	11.51	15.07	11.01	2.26	.037
(b) Habitat Maintenance	4.10	4.31	3.38	4.29	4.27	6.37	5.87	5.87	6.82	7.46	<1	N.S.
(c) Maintenance of Others	1.25	1.67	1.00	.92	1.84	1.88	1.05	1.39	1.85	2.92	3.34	.004
2. Leisure	21.75	24.66	28.10	22.76	15.78	12.52	18.12	20.27	16.66	23.58	6.70	.0001
(a) Co-Recreation	8.49	8.38	10.28	10.88	5.81	6.18	7.67	9.43	7.76	10.62	4.76	.0004
(b) Solitary Recreation	7.36	6.71	7.66	4.32	5.91	3.29	6.60	7.05	4.35	4.68	1.55	N.S.
(c) Relaxing	5.90	9.58	10.16	7.56	4.07	3.05	3.85	3.79	4.54	8.29	14.2	.0001
3. Self-Maintenance	6.48	7.71	8.89	6.92	9.23	7.81	7.77	7.83	7.61	6.94	4.97	.0003
4. Sleep	33.72	33.26	37.11	37.18	33.99	31.99	39.62	35.08	35.42	30.89	1.87	N.S.

*For all analyses, *df* between groups = 9, *df* error = 40.

Table VI-2

Comparison of Long and Short Missions

Variable	Mean % Long Missions (6)	Mean % Short Missions (4)	F Ratio*	Probability
1. Work	31.70	36.30	4.53	.03
(a) Total Marine Science	25.99	28.81	1.80	N.S.
(1)Direct Marine Support	13.76	14.62	<1	N.S.
(2)Marine Science Support	12.24	14.19	3.00	N.S.
(b) Habitat Maintenance	4.38	5.56	<1	N.S.
(c) Maintenance of Others	1.32	1.93	5.86	.01
2. Leisure	19.95	20.62	<1	N.S.
(a) Co-recreation	8.52	8.42	<1	N.S.
(b) Solitary Recreation	5.73	5.51	<1	N.S.
(c) Relaxing	5.70	6.71	1.40	N.S.
3. Self-maintenance	8.08	7.23	7.31	.009
4. Sleep	36.73	32.46	12.06	.002

*For all analyses, df between groups=1, df error=46.

The fact that Aquanauts on short missions worked significantly more than those on long missions is largely an artifact of food preparation. On all twenty-day missions, Aquanauts ate pre-packaged, frozen food provided by NASA. On three of the four short missions, Aquanauts had to prepare their own food using standard grocery store comestibles. Food preparation is coded as maintenance of others; significantly more time was spent on this component of work in short missions. Of particular interest is the fact that there was not a significant difference between long and short missions in the percent of Marine Science work accomplished. Thus, longer mission duration did not significantly reduce the percentage of total time Aquanauts were able or motivated to devote to scientific work.

Comparison of 60-Day Missions. The six twenty-day missions were organized as two sets of three missions with four engineers serving for thirty days each and rotating at the halfway point of each set. The two groups of three missions were compared by analysis of variance to determine whether any unpredicted differences were present in habitat behavior. The two sets of missions were comparable on the major activity categories; no significant differences were found. These findings, and those noted earlier, support the contention that differences between teams are primarily a function of group dynamics, team composition, and individual differences in motivation.

General Comments on Team Differences. It may be useful to make a few preliminary remarks on probable causes of the large differences across teams in performance (Marine Science and Total Work).

One characteristic of each mission is that groups began working at a given level (for example, 25% Marine Science per day) and varied around this mean. Psychologically, each group appears to have established an initial norm for work and to have generally maintained this level of output throughout the mission. This determination of performance by expectancy has been widely noted as a cognitive consistency phenomenon derived from the theory of cognitive dissonance (Festinger, 1957; Aronson and Carlsmith, 1962). The implication of this finding is that it will be advantageous for mission planners to make explicit the expected norms for performance. In TEKTITE, no transmission of expectancy from program personnel was planned or undertaken. This, of course, was because a goal of the research was to investigate the typesof norms established.

An important goal of later analyses will be to uncover reasons for the establishment of different norms and to specify personal characteristics of those who deviate from group norms. Group influence in small, isolated groups is extremely powerful, and subtle pressures are exerted to enforce conformity. Individual differences will be discussed in Section VIII.

One factor which appears to be strongly related to level of performance is crew composition, particularly in regard to the leadership role. In six missions, the team leader was the Scientific leader, in two missions the Engineer was the team leader and in two missions leadership changed. In the latter cases, the Engineer served as team leader for ten days; then, after engineer rotation, the Scientific leader served as team leader for the remainder of the mission.

Although the number of leaders in the different leadership roles is insufficient for statistical tests of significance, several tentative hypotheses about the leadership role can be advanced and may be subjected to test in subsequent research.

The differences in time spent in work between the top three teams and the bottom three teams are large (Mean Work-top three=38.7%; Mean Work-lowest three= 27.5%). The three teams showing the highest work output had a Scientist as team leader while the lowest three had an Engineer as team leader for all or part of the mission.

The leaders of high performing teams were not necessarily top performers (in terms of time spent in work). Indeed, the within-team ranks for the leaders of the top three were 1, 3 and 5 on work. In earlier studies (see Radloff and Helmreich, 1968) it has been noted that leaders of effective groups may not themselves perform particularly well. These differences in crew performance are probably due largely to the mission role of the leader. The objective of TEKTITE was to provide a base for scientific work. When a Scientist was team leader, his personal goals and mission goals coincided. The Engineer, on the other hand, was charged primarily with the maintenance of the habitat and was not directly involved in scientific research. Habitat maintenance took an average of 5.27% of mission time overall and did not differ significantly across missions; it is likely that an engineer who was primarily concerned with the effective performance of his engineering duties would not aid in setting high norms for scientific work. As a general rule, it would appear advisable to have mission leaders directly involved in primary mission objectives. An exception which seems to illustrate this point is found in the case of the mission which ranked 5th in performance and was initially led by an Engineer. The Engineer/team leader became actively involved in participating in the scientific research of the Scientist-Aquanauts. This involvement seems to have facilitated group performance.

Mention should be made of the possible effects of group emotionality on performance. Although analyses of affective states are being deferred to a later report, some comments based on general observations are in order. There is no evidence for any correlation between overall group relations and performance. Teams with close interpersonal relationships were found among those highest and those lowest on work. Similarly, there were groups at both ends of the performance continuum which had strong interpersonal conflicts and fairly low levels of cohesiveness. While analyses should show strong relationships between individual affective response and individual performance, the relationship between overall group affect and team performance appears to be nonlinear.

<u>Correlations Among Habitat Activities</u>. Tables VI-3 and VI-4 show the intercorrelations of observed categories of behavior inside the habitat for all Aquanauts and for Scientist-Aquanauts. The relationships shown in the tables give a clear picture of how various habitat activities related to one another. Since the components of composite variables had a highly consistent relationship with each other and with other variables, discussion will be of the correlations between independent and composite variables. The reader is referred to the tables for exposition of specific relationships.

Table VI-3

<u>Correlations Between Activity Variables (All Aquanauts)</u>*

	1	2	3	4	5	6	.	8	9	10	11	12
1. Work**	1.00											
2. Total Marine Science**	xxxx***	1.00										
3. Direct Marine Science	xxxx	xxxx	1.00									
4. Marine Science Support	xxxx	xxxx	.68	1.00								
5. Habitat Maintenance	xxxx	-.55	-.55	-.43	1.00							
6. Maintenance of Others	xxxx	.01	.01	.02	.24	1.00						
7. Leisure**	-.76	-.76	-.73	-.66	.17	-.01	1.00					
8. Co-recreation	-.44	-.49	-.47	-.43	.18	.05	xxxx	1.00				
9. Solitary Recreation	-.59	-.65	-.60	-.58	.23	-.08	xxxx	.04	1.00			
10. Relaxing	-.59	-.50	-.49	-.41	-.02	.01	xxxx	.57	.21	1.00		
11. Self-maintenance	-.07	.03	.08	-.06	-.14	-.03	-.18	-.34	.07	-.15	1.00	
12. Sleep	-.69	-.30	-.35	-.31	-.40	-.50	.09	-.06	.20	.04	.10	1.00

* N=48, with 46 <u>df</u> a correlation of .28 is significant at the .05 level and a correlation of .36 at the .01 level.
** Indicates a composite variable.
*** Correlations between components of a composite variable and the composite are indicated by xxxx.

Table VI-4

<u>Correlations Between Activity Variables (Scientists Only)</u>*

	1	2	3	4	5	6	7	8	9	10	11	12
1. Work**	1.00											
2. Total Marine Science**	xxxx***	1.00										
3. Direct Marine Science	xxxx	xxxx	1.00									
4. Marine Science Support	xxxx	xxxx	.49	1.00								
5. Habitat Maintenance	xxxx	.33	.22	.37	1.00							
6. Maintenance of Others	xxxx	.21	.20	.16	.15	1.00						
7. Leisure**	-.77	-.78	-.75	-.57	-.36	-.08	1.00					
8. Co-recreation	-.49	-.52	-.47	-.42	-.10	.02	xxxx	1.00				
9. Solitary Recreation	-.55	-.51	-.48	-.40	-.46	-.21	xxxx	-.05	1.00			
10. Relaxing	-.59	-.61	-.62	-.40	-.24	-.01	xxxx	.55	.18	1.00		
11. Self-maintenance	-.02	-.01	.05	-.10	-.12	.02	-.21	-.31	-.00	-.13	1.00	
12. Sleep	-.79	-.76	-.65	-.66	-.33	-.49	.25	.11	.38	.10	.02	1.00

* N=40, with 38 <u>df</u> a correlation of .31 is significant at the .05 level and a correlation of .40 at the .01 level.
** Indicates a composite variable.
*** Correlations between components of a composite variable and the composite are indicated by xxxx.

Considering first the correlations for the entire sample of Aquanauts (Table VI-3), there are strong negative correlations between Work and Sleep (-.69) and between Work and Leisure (-.76). Sleep and Leisure were uncorrelated (.09). Self-maintenance was not significantly correlated with Work (-.07), Sleep (.10) or Leisure (-.18); it did, however, have a significant negative correlation with co-recreation (-.34).

As can be seen in Table VI-4, the correlations for Scientist-Aquanauts are highly similar to those for the total population. As a result, the following discussion applies to all Aquanauts.

The patterns of correlations shown in both tables indicate that those who worked most spent less time both in leisure pursuits and in sleeping. This does not imply that those who worked most skimped on sleep and leisure to gain working time. The top ten Scientists on the work criterion averaged 8.5 hours a day working, 8 hours sleeping and almost 4 hours a day in leisure. It indicates, rather, that those low on the work measure spent a very high percentage of their day either sleeping or in leisure activities. (For example, the Aquanaut who worked least spent an average of 4.3 hours per day working, 9 hours per day on leisure, and 8.2 hours per day sleeping.)

Those who slept most were neither more nor less likely to spend much time in Leisure activities. Thus, while both Sleep and Leisure predict Work, they do not have a systematic relationship with one another.

Spending time diving did not result in devoting more time to Self-maintenance. In other words, spending more time in the water or in general work did not result in the use of more time for prophylactic and other hygienic activities. The significant negative correlation of self-maintenance with Co-recreation indicates that those who spent more time caring for themselves were less likely to participate in group recreational activities.

Since pre-dive baseline data on the correlations between Work, Leisure and Sleep are not available for the Aquanaut sample, it is impossible to state whether the correlations found among these variables in the habitat are a result of differential response to the isolated environment or are instead an extension of everyday life habits. However, given the large number of significant differences on predictive variables found between Aquanauts scoring high and those scoring low on the Work criterion, it is reasonable to hypothesize that the relationships found in TEKTITE are indeed related to pre-mission life patterns. If this proposition is correct, then knowledge of applicants' customary life patterns would provide a battery of extremely effective predictors which could be used in selection of candidates for sensitive and demanding missions. It should be noted that self-report does not provide a generally reliable data base for evaluation of individual characteristics (see Radloff and Helmreich, 1968 for a discussion of the relative merits of data sources). Nevertheless, the relationships discussed above are so strong that a recommendation to evaluate normal life patterns as potential predictors of performance is in order. Available data are generally weak, yet, as has been noted, past behavior remains the best predictor of future behavior. The major problem is to obtain objective, reliable data on individuals using non-reactive measures. This presents a major challenge for later research.

Gregariousness. Patterns of social interaction, their changes over time and correlations with activity variables form one of the most interesting components of the research. Data on communication and social behavior were collected on the Aquanaut Status Record, the Meal Record, the Communication Record, and video tape. Because of the complexity and volume of these data, detailed analyses have been deferred; however, a preliminary examination of several of the variables measured indicates the power and importance of this area.

Correlations between the overall gregariousness of each Aquanaut (time spent with other Aquanauts in conversation) and Total Marine Science and between time spent communicating with the topside command van and Total Marine Science were computed for Scientist-Aquanauts. The correlation between gregariousness and Total Marine Science was .59 ($p < .01$) showing clearly that interaction with peers is positively associated with productivity. This finding strongly replicates the results on gregariousness among Aquanauts found in SEALAB II. Communicating with topside was also positively related to time spent on Marine Science ($r = .35$, $p < .05$). Those who spent most time communicating with topside personnel also spent most time performing Marine Science work. These findings appear to contradict results noted in SEALAB II where communications with topside was associated with poor performance. This apparent contradiction points out the need for precise specification of variables and for detailed interpretations of obtained results. In SEALAB II, only social communication with topside initiated by Aquanauts were recorded where in TEKTITE, all communications, social and operational, initiated by the surface or by Aquanauts, were monitored and noted (see Table II-2 for a description of the information recorded). Although complete data on the nature of each conversation are coded, in this preliminary computation only total time spent in communication was used to provide an overall look at the effects of communication. It is probable that subsequent analyses will reveal that Aquanaut-initiated, social communication with the surface is associated with poor performance while operational communication is a positive correlate of work.

The first general conclusion which can be drawn from the data is that individual gregariousness is positively associated with performance. The isolation of conditions which promote or hinder gregariousness will be a major goal of later analyses of the TEKTITE data. In any event, this preliminary look at the information collected suggests that the available data on social interactions will account for much of the observed variance in group behavior and performance.

Comparison of Male and Female Aquanauts. One of the questions of greatest interest concerning TEKTITE is the behavior of the team of female Aquanauts in contrast with that of male teams. Unfortunately, the assignment of only one female team and a number of other external factors make it impossible to draw firm conclusions about the two populations. The reader should, accordingly, keep in mind the fact that the differences described below probably reflect less on the relative capabilities of the two sexes than on social and environmental factors. These factors will be discussed after presentation of the obtained results.

Comparisons between the five females and the forty-three males were made by unweighted means analysis of variance. On the activity criteria, the females worked significantly more than the combined male population ($F = 12.49$, $p < .002$), spent more time on Marine Science ($F = 5.56$, $p < .025$) and spent <u>less</u> time on Leisure ($F = 12.08$, $p < .002$). They did not differ significantly from the males in total sleep time, time spent in habitat maintenance and time spent on self-maintenance.

The high work output of the female team implies that females are capable of maintaining a work pace equal to that of males in an underwater habitat. The fact that the females measured significantly higher than males on the Work and Marine Science criteria could be an indication of the natural superiority of women or of differential motivation. Consideration of social psychological factors suggests the latter interpretation although causal forces cannot be extracted from the data.

Some of the forces which probably acted to increase motivation in the female team can be isolated. These include selection procedures, potential effects of the mission, on-site support and publicity about the role of women in undersea research. Considering these in order, that only one of 10 missions was for females and that it was the first female saturation dive undertaken probably led to more intensive screening and, in general, more rigorous criteria for selection than were applied to male candidates. This probably resulted in more of a sense of uniqueness and higher motivation to achieve than was present in most male Aquanauts. Directly related to this was the first-and-only-of type category of the mission. Comments from program personnel and the scientific community depicted this mission as determining the feasibility of women participating in both undersea and space exploration. This factor alone doubtless produced a strong pressure to produce and to excell on each of the female Aquanauts. Another factor which seems to have contributed to the high work output of the female team was the fact that surface support personnel were more highly motivated to provide assistance to the female team. These natural and commendable reactions undoubtedly made conditions somewhat more propitious than they were for male teams. Finally, the publicity and press coverage surrounding the female mission, which far exceeded that accorded any other mission, unquestionably caused members of this team to be more conscious of their performance and more highly motivated to look good in comparison with other teams.

None of the factors cited above reflect any discredit on the performance of the female mission, which was excellent on an absolute basis; they are cited to illustrate the importance of motivational factors.

The conclusion that motivational factors probably account for most of the obtained performance differences is supported by the general lack of differences between female and male Aquanauts on demographic and personality factors related to diving performance. Female Aquanauts were compared with male Aquanauts by unweighted means analysis of variance on general demographic and personality variables. A significant difference was found only on mean age--the females as a group were significantly younger than the males ($\bar{X} = 32.7$ for males, 27.0 for females; $F = 5.43$, p .025). Among the variables on which there was no difference were years of scuba experience, IQ, religious activity, and value structure (as measured by the Allport-Vernon-Lindzey). The two groups were also compared on variables derived from the Life History Questionnaire. Significant differences were found on only four variables. These were: parental physical affection (females received more); school performance (females received higher grades); fights with peers (females had fewer); and work during summer months (females were less likely to have worked). These contrasts are all in agreement with sex differences in the American population. The remarkable fact, then, is how similar the male and female groups were on all predictive measures.

In summary, female Aquanauts logged more Marine Science activity and more Total Work than did males. They were remarkably similar to males on personality and demographic variables and a hypothesis that their higher performance was a result of higher motivation seems warranted. It does seem possible to conclude that female Aquanauts can perform as effectively as males in a saturation diving operation such as TEKTITE.

Scientist-Engineer Relations. One of the questions frequently debated in social psychology is the nature of relations between individuals with differing goals and orientations who are forced into close interaction. The issue has been raised, in particular in the American space program where scientists and engineers are often described as having incompatible goals which make professional and social interaction difficult. A valid concern is how a mixed crew of Engineer-Pilot Astronauts and Scientist-Astronauts would fare in close contact on a long-duration spaceflight. Could individuals with divergent roles and goals be compatible in an isolated environment for long periods of time where no opportunity for escape is present?

TEKTITE II provided one opportunity to evaluate the interactions of mixed groups in a natural setting. Each Aquanaut team was composed of four Scientists and one Engineer: the goal of the Scientists was Marine Research while the Engineer was charged with the operation and maintenance of the habitat. The opportunities for misunderstanding and conflict were many--over work goals and schedules, space utilization, and social interests.

In general, relations between Scientist-Aquanauts and Engineer-Aquanauts were excellent. In addition to the shared concern with the overall success of the project, most teams developed effective techniques to assure harmony and productivity in the closed environment.

One aspect of Scientist-Engineer relations, however, appears to have a systematic relationship with performance and group cohesiveness. This is the involvement of Engineers in scientific work and Scientists in engineering activities. It has already been noted that teams wtth Engineers as leaders for part or all of the mission accomplished less Marine Science work than teams with Scientists as leaders. This was attributed to non-congruence between the Engineer's mission role and the scientific goals of the other Aquanauts. However, overall performance on Marine Science was notably higher where the Engineer-leader became actively involved in the scientific programs of the other Aquanauts. It seems likely that an extension of this phenomenon may be an important factor in the compatibility and productivity of isolated groups composed of individuals with divergent interests and goals.

Helmreich and Radloff (1969) proposed that the most effective social organization for a confined environment (such as a long-duration space mission) is one in which individuals have unique skills and knowledge which they communicate to others who are motivated to learn and who have their own skills to share. This form of interaction with each individual serving as both a teacher and a learner should maximize the rewards possible in a closed environment and should also increase interpersonal understanding.

It was possible to examine aspects of this type of relationship in the TEKTITE setting. We assumed that the greatest Engineer-Scientist compatibility would be achieved when the Engineer became actively involved in Marine Science projects and when, conversely, the Scientists played a significant role in engineering/Habitat Maintenance activities. A preliminary examination of the data supports this hypothesis. There was great variablity on these measures. The average of Marine Science time for the three Engineers who became most involved in working with Scientists was 22.05%. The average for the three Engineers who participated least in scientific work was 7.89% Marine Science. This sharing (or avoidance) was reflected in the participation of Scientists in engineering duties. Mean Habitat Maintenance by Scientist-Aquanauts on the three missions where the Engineer took part most in scientific work was 3.59%, while on the three teams where the Engineer was least active in Marine Science, the Habitat Maintenance mean for Scientists was 2.07%. Preliminary analyses indicate that the teams with a high degree of shared scientific-engineering activity were more cohesive and compatible than those where Scientists and Engineers did not participate in each other's work.

Overall performance was also markedly influenced by Scientist-Engineer interaction. The mean for Total Marine Science of the three teams where the Engineer-Scientist sharing was highest was 29.95% while the Total Marine Science score for the three teams with the lowest amount of cross-participation was 23.61%. This is a mean difference of more than an hour and a half per day.

The implications of these findings are that in selecting professionally mixed teams for isolated environments, not only the professional qualifications but also the breadth of the candidate's interests should be considered. The individual who is not only skilled in his own profession but eager to acquire knowledge about other lines of endeavor should be the most effective type of group member. This reasoning would suggest that the individual who is single-mindedly dedicated to his particular professional aim would not make an effective member of a mixed crew. That sharing of diverse interests aided cohesiveness and compatibility was also demonstrated in debriefing of several Scientist-Aquanauts who remarked that one of the high points of their experience was the exchange of professional information with other scientists who had completely different professional backgrounds.

An important aspect of subsequent analyses will be an attempt to isolate background characteristics which can predict whether or not an individual will enter into cross-professional exchange. This area appears to be of sufficient importance to merit intensive investigation.

Effects of Partial Crew Rotation. In two missions, the Engineer was replaced at the midpoint of the mission. The effects of the rotation of one crew member on the behavior of the remaining members are of both theoretical and practical importance. Because there are large differences in behavior as a function of time in habitat (which will be discussed in Section VII), the analysis of the effects of a crew change in a middle of a twenty-day mission must take into account the normal changes over time. As a first analysis of these data, the behavior of the four Scientist-Aquanauts before and after Engineer change was compared with that of the four Scientists-Aquanauts during comparable time periods in the four twenty-day missions without crew rotation. This comparison was done by unweighted means analysis of variance contrasting missions without rotation amd missions with rotation (between) and first-half of mission with second-half of mission (within). In other words, the first and second halves of missions with an Engineer change (rotation was at mission midpoint), were compared with the first and second halves of the four twenty-day missions without an Engineer change. The latter missions served as a control for the former. In this analysis, behavioral effects of crew shift will be reflected in a significant group (rotation or non-rotation) by trials (first-half versus second-half) interaction.* Means and significance levels for activity variables are shown in Table VI-5.

As can be seen in the table, changing a crew member did not significantly affect the major performance criteria, Total Marine Science and Total Work. There was also no significant effect on Sleep and Total Leisure.

Social relations were significantly influenced by Engineer change. This is shown in the significant interactions for Co-recreation, Solitary Recreation, and Gregariousness. As can be seen in Table VI-5, the percentage of time spent in Total Leisure did not differ between rotated and unrotated missions over time (the *F*-ratio is less than 1). However, the types of leisure activities did differ significantly as a function of Engineer change. In missions where the Engineer changed, Co-recreation *decreased* after the shift while in missions without rotation there was an increase in Co-recreation during the corresponding time period. Exactly the opposite pattern is shown in the data on Solitary Recreation. An Engineer change was followed by an increase in Solitary Leisure while intact groups showed decreased Solitary Recreation over time.

The effect of crew change on Gregariousness (as measured by total conversation) is highly significant. While social interaction increased between the first and last half of missions without rotation, there was a dramatic drop when a new member entered the group.

Because of the limited number of cases, generalizations about the effects of partial crew rotation are unwarranted. However, the fact that a member of an isolated small group could be replaced in mid-mission without an adverse effect on performance is worthy of note, particularly since the change was associated with significant changes in social behavior. The shifts in leisure activity and gregariousness after rotation are in the direction of less group cohesiveness. This pattern is consistent with a large research literature indicating that the addition of a new member to a cohesive, ongoing group produces at least temporary disruption.

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*By a significant interaction we mean that the pattern of scores between the first and second halves of the mission differs in the two groups. For example, if Solitary Recreation increased after Engineer change in rotated crews but decreased in non-rotated crews, there would be an interaction effect.

Table VI-5

Effects of Time and Engineer Rotation on Habitat Activities of Scientists

Variable	Mean % 1st Half (Before Engineer Change)	Mean % 2nd Half (After Engineer Change)	Interaction F-Ratio	Probability
Total Marine Science				
Group				
Long Missions with Engineer Change 2 Missions; 8 Scientists	27.9	28.2	<1	N.S.
Long Missions Without Engineer Change 4 Missions; 16 Scientists	28.5	27.7		
Total Work				
Long Missions with Engineer Change	32.4	31.2	<1	N.S.
Long Missions without Engineer Change	32.9	31.2		
Sleep				
Long Missions with Engineer Change	35.9	38.5	<1	N.S.
Long Mission without Engineer change	36.7	38.1		
Total Leisure				
Long Missions with Engineer Change	20.6	20.7	<1	N.S.
Long Missions without Engineer Change	18.4	18.2		
Co-recreation				
Long Missions with Engineer Change	10.7	9.5	5.61	.02
Long Missions without Engineer Change	7.1	7.7		

Table VI-5
page 2

Variable	Mean % 1st Half (Before Engineer Change)	Mean % 2nd Half (After Engineer Change)	Interaction F-Ratio	Probability
Solitary Recreation				
Long Missions with Engineer Change	4.1	5.4	3.98	.05
Long Missions without Engineer Change	5.6	5.2		
Gregariousness (Time spent communicating)				
Long Missions with Engineer Change	33.8	28.5	16.2	.0008
Long Missions without Engineer Change	28.3	30.1		

It should be emphasized that the crewman change in TEKTITE involved the replacement of a peripheral member. The Engineer is peripheral in the sense that his role is not directly related to the scientific goals of the other team members. Replacing a Scientist-Aquanaut might have a far greater impact on performance. In any case, TEKTITE Aquanauts managed crew rotation without major conflict or work decrement.

VII. Time Effects on Behavior

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Throughout this report we have used observational data primarily in highly reduced, summary form. For example, we have referred to the total percentage of time Aquanauts slept during missions, but have, in general, ignored the ways in which time spent sleeping changed during the course of a mission. It seems clear that collapsing time series data during initial analyses is justified, yet it is equally clear that much richness remains to be tapped. Such analyses will undoubtedly reveal details and indicate mechanisms only vaguely suggested by first order generalizations based on summary data.

The problems presented by time series analyses are difficult but not insurmountable. There is a risk of being simply inundated by mounds of detail. Here, as elsewhere, it makes sense first to determine at a molar level if a phenomenon holds interest, then, if it appears promising, to examine it in more detail. Accordingly, our first approach to time series analyses has been simply to compare time spent in various activities during the first half of a mission with time spent on the same activities during the second half. This "split mission" comparison indicates differences not only within missions, but suggests different patterns of change between short (14 day) and long (20 day) missions.

Specifically, trials by subjects analyses of variance were computed for two groups: those Aquanauts participating in the short missions and those participating in the long missions. In addition, these analyses were run by team both for Scientists only and for all five Aquanauts. Since patterns of significance are almost identical with and without the Engineers, the results reported below refer to the analyses including all Aquanauts. Thus, using our standard activity variables, differences between the first-half and last-half of both the short and the long missions were examined (see Table VII-1).

The most striking finding from this analysis is that 8 of the 9 variables used showed a significant change from the first-half to the last-half of the short missions, but that only 4 variables were significant in the case of the longer missions. This suggests that the long missions were long enough to gain some stability over time, but that the short missions were subject to a "Night-Before-Christmas" excitement effect, i.e., people entered the short missions excited, worked very hard initially, burned out somewhat, and then relaxed more during the second-half of the mission. The data bear out the tenability of this notion.

Of the significant variables for the short mission, 4 were highly significant ($p < .001$); these were: Total Work,* Total Leisure,* Total Marine Science, and Co-recreation. Direct Marine Science, Habitat Maintenance, and Gregariousness differed less significantly ($p < .01$) than the four mentioned above but were still

*Total Work is a composite variable consisting of: Direct Marine Science, Marine Science Support, Habitat Maintenance, and Maintenance of Others. Total Leisure consists of: Co-recreation, Solitary Recreation, and Relaxing, Resting and Idling.

Table VII-1

Changes in Activity Variables Between First and Second Halves of Long and Short Missions

Variable	Long Missions (6 Missions, N=30)[1]				Short Missions (4 Missions, N-20)[2]			
	Mean % 1st Half	Mean % 2nd Half	Trial F-Ratio	Probability	Mean % 1st Half	Mean % 2nd Half	Trial F-Ratio	Probability
Total Work	31.49	29.34	5.59	.025	40.00	32.75	26.79	.0002
Habitat Maintenance	5.45	4.23	15.82	.0008	6.39	4.60	11.55	.0039
Total Marine Science	26.93	26.03	<1	N.S.	31.54	26.33	20.93	.0005
Direct Marine Science	12.88	14.35	4.41	.044	15.95	13.42	11.03	.0045
Total Leisure	19.59	19.93	<1	N.S.	17.86	23.47	30.64	.0001
Co-recreation	8.47	8.36	<1	N.S.	6.37	10.67	101.46	.0000
Solitary Recreation	5.57	6.17	1.80	N.S.	5.41	5.64	<1	N.S.
Sleep	34.49	36.30	15.87	.0008	31.35	33.44	5.99	.025
Gregariousness	32.53	31.47	2.82	N.S.	30.71	32.81	12.82	.0028

[1] For Long Mission analyses of variance, *df* = 1 and 24.

[2] For Short Mission analyses of variance, *df* = 1 and 16.

more significant than Sleep ($\underline{p} < .03$). Only Solitary Recreation was not significant. In all cases, time spent working or in categories associated with Total Work decreased from the first to the second half of the short missions, while time spent in Total Leisure pursuits or Sleeping increased.

Less work and more leisure during the second-half of the mission was also the rule for long missions, but the differences are not so striking. Only 4 variables differed significantly: Habitat Maintenance and Sleep were both highly significant ($\underline{p} < .001$); Total Work ($\underline{p} < .03$) and Direct Marine Science ($\underline{p} < .05$). Neither Total Leisure nor Total Marine Science differed significantly. It appears that the difference in Total Work is almost totally accounted for by differences in time spent on Habitat Maintenance. Thus it is not unreasonable to claim that, at least with regard to first-half--last-half comparisons, the long missions evidence greater patterns of stability than do the short missions.

Totals, percentages, and means all represent safe and familiar computational ground. Analysis of variance and probabilistic statements of significance are common enough tools for most social scientists. With time series data we are on less familiar ground. Thus, for our next step in examining the data, we regarded ourselves as well advised to revert to one of the most primitive yet clearest methods of data presentation--graphic representation. Graphs were prepared (by computer) which depicted the daily flow of each Aquanaut's activity. A sample extracted from one of these graphs is included here (Figure VII-1).

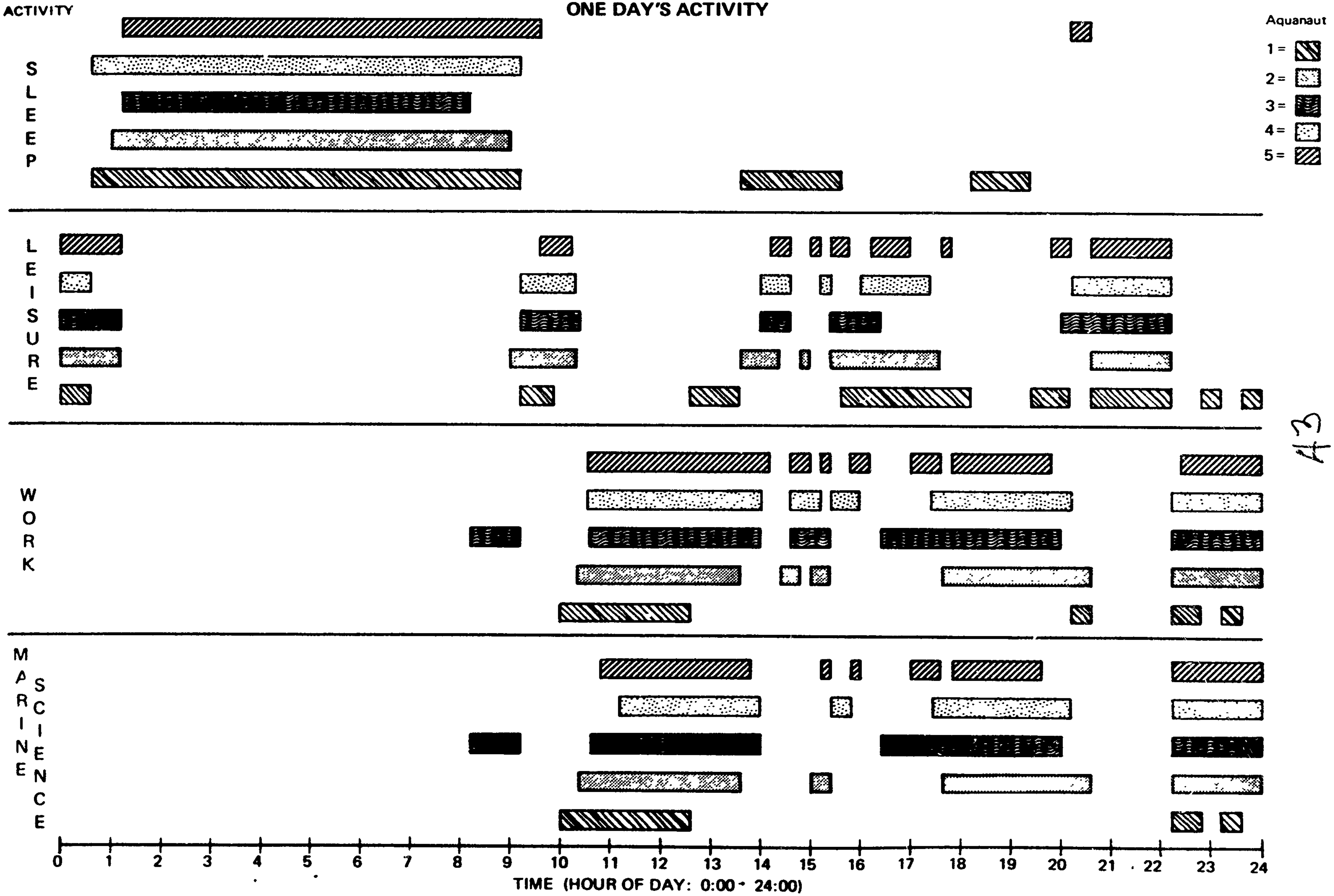
These graphs made manifestly clear one fact which we had previously suspected: a "day" running from midnight to midnight would not do as our next unit of analysis (after the first-half--last-half mission split). It is worth pointing out here that the analyses reported above were indeed based on mission splits--the observations were divided at the midpoint and percentages computed for the various activity variables for all observations in the first-half and then in the second-half of the missions. No assumptions involving days were necessary. But a day--defined as encompassing a person's major period of wakefulness--is a logical unit for time series analysis. Careful examination of the graphs described above indicates that a "day" running from 3 a.m. to 3 a.m. will, in almost all cases, satisfy the preceding definition. It has accordingly been adopted as the TEKTITE Standard Day for future analyses.

At this point, an embarrassing wealth of questions suggest themselves; hopefully, some answers will be forthcoming from future work. In the previous section, for example, perturbations caused by a crew change were discussed. How long these perturbations existed in various types of activity is certainly a researchable question.

The TEKTITE data indicates, as does most previous work with group processes, the strong way in which groups seem to form and enforce norms for various behaviors. It would be useful to know not only how early in time norms (especially Work norms) can be determined but what accounts for later deviations from these norms.

It is generally conceded that the greater group cohesiveness, i.e., the more the members of a group like the other members, the more each member will strive to carry out the group's goals. In the case of TEKTITE II, this should be evidenced by more Total Marine Science Work. It seems likely, but not yet tested, that productive groups will evidence patterns of cohesiveness early, and will increase in

FIGURE VII-1
ONE DAY'S ACTIVITY



cohesiveness over time, while less productive groups will be less cohesive early and will decrease in cohesiveness.

Totally unexplored to date are the Mood Adjective Checklist data, collected (when all went according to plan) twice daily. Beginning traditionally, it makes sense to first explore correlations among in-habitat behavior variables and MACL variables. But the last few years have seen the development of statistical techniques designed to extract causal connections from correlational data (see Borgatta, 1969). Such techniques depend on being able to assume a time sequence among variables and thus seem especially well-suited to the data at hand. Even the "unobtrusive measure" of times when Aquanauts failed to fill out the MACL can form an interesting variable. Correlates and causal connections of this "forgetting" behavior may indeed prove fruitful to explore.

Clearly, questions are more numerous than answers at this point. Two conclusions, however, do seem warranted. The first is simply that a two-week mission is not a sufficiently good analogue for long-term missions but that a three-week mission probably is. Given what we now know, it seems reasonable that findings from three-week missions will generalize to groups confined for periods of longer duration. The second, rather obviously, is the fact that a study of patterns of variables over time can immeasurably deepen our understanding of group processes and can increase the certainty of predictive statements involving the objective variables discussed throughout this report. Not only should this make for more precise theoretical descriptions of the phenomena, but (remembering Kurt Lewin's dictum that "there is nothing so practical as a good theory") should also allow for more precise interventions in on-going groups to achieve desired outcomes.

VIII. Prediction of In-Habitat Behavior

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The development of predictive tests has been a major preoccupation of psychology. Countless hours have been spent on the design of paper and pencil measures to predict job performance, psychological states and a variety of other behaviors. One practical need for successful prediction is obvious. When behavior can be explained as a function of antecedent conditions, individuals can be selected who have the maximum chance of success in any given role. A good example of a situation demanding precise prediction is the selection of Astronauts. Training costs are high in terms of money and time, mission costs are enormous, and the psychological or physical failure of one man could not only abort a mission but also imperil the lives of teammates. Although selection of Pilot-Astronauts has been successful to date, the overall state of the art in psychological selection leaves much room for improvement.

As we mentioned in Section III, demographic variables appear to be most successful in prediction of behavior but have generally not been used or studied systematically. We have described the development of the Life History Questionnaire as an instrument for demographic investigation and prediction. In this section we will discuss the effectiveness of pre-mission predictive variables in accounting for the actual behavior recorded during missions.

Criteria for Prediction. One of the most persistent problems in the development of predictive instruments is obtaining valid, quantifiable criteria of performance. For example, attempts to predict adult mental health as a function of childhood experiences face the problem of defining mental health in an objective, quantifiable manner.

One solution has been to employ dichotomous criteria such as passing or failing a course, completion or non-completion of pilot training, etc. Considerable success has been obtained in predicting such dichotomous criterion variables. However, this type of prediction has serious limitations because it forces a broad spectrum of behavior into a limited number of arbitrary categories. It does not, for example, provide information on the difference between individuals who barely meet the criterion and those whose performance is outstanding. This is particularly important when selecting from a population of highly qualified candidates, all of whom can meet the criterion. The task in this case is to discriminate between those whose performance will be superb and those whose will be merely excellent.

We have pointed out that one of the reasons for our enthusiasm about TEKTITE was the availability of continuous, objective, behavioral criteria. With high reliability, a large number of observations (2866 to 4770 records on each criterion per Aquanaut depending on mission length), and large individual differences, the project provided a magnificent research setting for the investigation of predictive measures. For the purposes of this discussion, we have chosen the criterion of

Total Marine Science work performed by Scientist-Aquanauts. The Total Marine Science score is the sum of time spent in Direct Marine Science and Marine Science Support expressed as a percentage of total mission time. This criterion seems most appropriate for a first cut of the data since the expressed goal of the project was the accomplishment of Marine Scientific work by Scientists.

Other criteria of performance, activity, and social behavior have been formed for all Aquanauts and for sub-groups. Correlates of these measures will be presented in detail in subsequent reports. Among these are Total Work, Gregariousness, Leisure Activities and Sleep Cycles.

Selection of Aquanauts. Because of our interest in obtaining a wide range of individual differences on criterion measures, no psychological selection of Aquanauts was undertaken other than superficial screening for gross psychopathological disorders. No use was made of available predictive measures. Scientist-Aquanauts were selected on the basis of the merits of their proposed research while Engineers were chosen to provide a broad range of experience and professional skills. Employing these selection processes resulted in enormous variability on all behavioral measures, as we have illustrated in Section VI.

Forming Conceptual Predictors. We reported in our introductory discussion that the investigator can create any number of conceptual variables from the matrix of yearly responses to the Life History Questionnaire. An example of a general variable would be computation of the mean response on hometown size or family size over the entire age range. Another type of general variable would be the number of changes found on a variable over a specified time period--for example, changes in health. More detailed predictors can also be created by looking at responses for a limited age range or by computing the direction and magnitude of differences between one age range and another--an example of the latter would be a variable formed by taking the signed difference in religious activity between ages 6-12 and 12-18. Using program LIHAN we can form variables to test many theoretical hypotheses about the relative importance of age periods and about the effects of perturbations in experience on later behavior.

Clearly, the number of conceptual variables that can be formed from the LHQ is almost infinite, tempting the researcher to ever finer cuts of the data. However, at this stage in our research in the use of the LHQ it has seemed wiser deliberately to resist this temptation and first to concentrate on rather gross conceptual variables. Accordingly, we have, on the basis of *a priori* assumptions, created three sets of conceptual variables.

The 39 predictors formed are listed in Table VIII-1, which also shows their correlations with the Total Marine Science criterion. The first conceptual set, which we have designated E or Environmental variables, consists of 17 variables which appear to reflect important environmental influences on the developing individual. These include such items as size of hometown, family size, parental employment, and health. The statistic employed is the mean computed for the maximum range of ages available. The second group, I or Individual variables, is composed of 12 predictors showing individual reactions during youth. This set includes items such as school performance, clashes with authority, and financial

Table VIII-1

Correlations of Predictive Variables with Total Marine Science

I. General Variables

Variable Name	TOTAL MARINE SCIENCE (Scientists only, N=40)[1]
1. Age	-.13
2. Years SCUBA experience	-.09
3. Participation in religious activity	-.35*
4. Father's education	-.18
5. Mother's education	.00
6. A-V-L Theoretical	.15
7. A-V-L Economic	-.17
8. A-V-L Aesthetic	.18
9. A-V-L Social	-.07
10. A-V-L Political	.09
11. A-V-L Religious	-.11
12. IQ	.51**
13. Birth order	.05

II. Life History Questionnaire Variables

Variable Name	Category[2]	
14. Hometown size	E	-.31*
15. Condition of home	E	-.10
16. Family size	E	-.33*
17. Clothing quality	E	-.37*
18. Food quality	E	.08
19. Father's employment	E	.17
20. Mother's employment	E	-.04
21. Height	E	.05
22. Weight	E	.06
23. Health	E	.21
24. School type	E	-.20
25. Size of school	E	.17
26. Parental praise	E	.07
27. Parental physical affection	E	.24
28. Parental criticism	E	-.15
29. Parental punishment	E	-.15
30. Community homogeneity	E	-.15
31. School performance	I	.47**
32. Athletic honors	I	-.08
33. Intellectual honors	I	.05
34. Other honors	I	-.05
35. Religious activity	I	-.31*
36. Going out at night	I	.24
37. Dating	I	-.09
38. Fights with peers	I	-.01
39. Clashes with authority	I	-.10
40. Financial independence	I	.48**

Table VIII-1
page 2

Variable Name	Category	TOTAL MARINE SCIENCE
41. Work (school year)	I	.22
42. Work (summer)	I	-.07
43. Hometown size	C	.13
44. Type of residence	C	.16
45. Family size	C	-.11
46. Clothing quality	C	-.32*
47. Father's employment	C	-.22
48. Mother's employment	C	.00
49. Height	C	-.04
50. Health	C	.17
51. School size	C	.07
52. School performance	C	.07

[1]With an N of 40 (38 df), a correlation of .27 is significant at the 10% level, a correlation of .30 is significant at the 5% level and a correlation of .39 at the 1% level.

[2]E refers to Environmental variables, I refers to Individual motivational variable, C refers to variables denoting number of Changes on the variable.

*$p < .05$.

**$p < .01$.

independence. Again, the statistic computed is the mean of responses during all relevant years (for example, school performance covers ages 6-18). The assignment of particular variables to either the E or I category is arbitrary and is done for convenience in preliminary analysis. Some variables, such as work during childhood, could reflect either environmental pressures, such as poverty or individual motivation. For the present analysis, this distinction is not crucial.

The third set of variables, C or Change variables, is composed of 10 items showing changes on theoretically important variables such as family size, academic performance and health. Each score in this set shows the total number of changes on the selected item for the entire range of ages measured.

Correlations of Predictors with Total Marine Science. The correlations between predictive variables and the criterion are shown in Table VIII-1. The first thirteen variables are general background information while the variables derived from the LHQ matrix are items 14 through 52. Looking first at the general variables, only participation in religious activity and intelligence are significantly correlated with the criterion. Less frequent attendance at religious services is associated with higher Marine Science scores. Higher intelligence is also associated with superior performance. This finding is somewhat surprising as the Scientist-Aquanauts are drawn from the upper ranges of intelligence in the general population. The strength of the correlation indicates that measured intelligence is a powerful correlate of performance, even when the predictor population has a highly truncated distribution.

The fact that neither age nor years of diving experience were correlated with the criterion supports a notion that motivational factors more than experience are prime determinants of performance in a situation such as TEKTITE. In SEALAB II also, there were no significant correlations between age and performance, and diving experience and performance.

Three of the E category LHQ variables were significantly correlated with the criterion. These were hometown size, family size, and clothing quality. As in SEALAB II, Aquanauts from small town showed higher performance (see Radloff and Helmreich, 1968, for a discussion of this variable). Those from smaller families also achieved more Marine Science, perhaps indicating more parental stimulation of children in smaller nuclear families. The negative relationship between clothing quality in childhood and the criterion may be a reflection of higher motivation among those who have achieved professional status from lower social origins.

Three of the I LHQ variables also correlated significantly with Total Marine Science. They were: academic performance, religious activity, and financial independence. The academic performance variable (showing higher scientific achievement as a function of superior school performance during youth) parallels the correlation between IQ and the criterion. Because this variable is highly objective and strongly related to the criterion, a more detailed analysis was conducted using additional variables defined for specific age ranges. Correlations between academic performance during elementary school (ages 6-12), junior high school (ages 13-15) and high school (ages 16-18) and the criterion were computed. The positive relationship between scholastic achievement and the criterion was strong for elementary school, weaker in junior high school, and very small during high school. The mechanisms responsible for this are still unclear. What is clear is that a total response such as academic performance overall may obscure more crucial predictors. In the example at hand, high school performance does not discriminate, while grade school achievement does. This suggests that patterns of responses and responses at different ages need careful investigation and that the LHQ uniquely provides the necessary information.

The negative relationship between youthful religious activity and performance is also parallel to that between adult behavior and the criterion. It implies that families with less religious orientation foster more scientific motivation in their offspring. The significance of this variable will have to be investigated in additional research.

The positive relationship between financial independence and the criterion supports an hypothesis that those achieving autonomy early are most likely to be highly productive adults.

The Change LHQ variable defining variations in clothing quality during childhood correlated significantly with the criterion, but negatively, indicating that changes in family social status during childhood may have an adverse effect on later performance. Considering this variable in contrast with the previously noted finding that lower social status (as reflected in poorer clothing) is a positive predictor of performance, the complexities of demographic interpretation and prediction become evident. A testable hyothesis is that those who become effective adult scientists tend to originate in lower socio-economic strata and to come from families which are not socially mobile. In other words, coming from a lower class family may have a positive influence on performance but not if the family is upwardly mobile. This is pure speculation, but it is an example of the type of hypotheses which can be tested using data derived from the LHQ.

It should be pointed out that the relationships which have been discussed above are only those where correlations with the criterion were significant at better than the 5% level. Many other variables show strong trends (often curvilinear) and discriminate between subgroups of the Aquanaut population.

<u>Comparison of Top and Bottom Aquanauts</u>. Another example of the discriminatory power of the variables employed is a comparison of scores on predictive variables of the 10 Scientist-Aquanauts composing the top 25% of the sample on the criterion with the scores of the ten with the lowest Marine Science output. An analysis of variance contrasting the top 25% of the sample with the bottom 25% was computed for each predictive variable. The obtained results reinforce the argument that demographic predictors can effectively differentiate between those who will perform adequately in such an environment and those who will do extremely well. The two groups differed significantly (with a probability less than .05) on 25% of the items while 12% of the items in the variable pool discriminated between the two groups with a probability less than .01.

Many of the variables which significantly differentiated the two groups have been discussed in reference to overall correlations. However, a number of variables which have not yet been mentioned are significant predictors of extremes of performance. These include health, family mobility (as shown by number of changes in hometown size), changes in family size, economic orientation (measured by the Allport-Vernon-Lindzey Study of Values) and birth order.

Health during childhood and youth differentiates among Aqunauats but in a counter-intuitive way.' The top performers had significantly poorer health than the lowest 25% ($F = 20.44$, $p < .001$). Again, a more detailed analysis of life history clarifies this result. Although the groups show a highly significant overall difference, this is caused by large differences during early school years (ages 6-12), as the groups do not differ significantly in earliest childhood or in adolescence. A preliminary hypothesis is that physical restriction because of ill health in early school years may stimulate interest in intellectual and scientific pursuits (perhaps a comment on the intellectual excitement engendered by typical elementary education?). Later good health may be associated with heightened interest in outdoor activities, perhaps as a psychological compensation for early restriction. We have tentatively christened this phenomenon the "Teddy Roosevelt Effect" and will explore its implications more fully in subsequent research.

Families of the high achieving ten moved significantly more than those of the lower group ($F = 4.11$, $p < .05$) but the top group experienced fewer changes in the composition of the nuclear family ($F = 4.62$, $p < .05$). Thus both disruptions due to geographical change and disruptions or change in family composition appear to be associated with performance, but in opposite directions. The low performing group of Aquanauts scored significantly higher on the Economic scale of the A-V-L ($F = 7.89$, $p < .01$). One interpretation of this finding is that those with high economic values were more motivated by the fame and profit potential involved in being an Aquanaut than by scientific interest and sought more the designation "Aquanaut" than the opportunity to conduct research in the undersea environment.

An additional significant difference between the two groups was in birth order. Members of the top performing group were more likely to be first-born in their families than were those in the bottom group ($F = 4.23$, $p < .05$). This significant difference between the two groups is in the opposite direction from that found in SEALAB II (where first and only-borns performed significantly less well than later-borns) but was predicted. As mentioned in the introduction, the stress level induced in the shallow, warm-water habitat was assumed on *a priori* bases to be significantly lower than that created in the more cramped habitat located at 200 feet in murky, cold water in SEALAB. Where stress levels are low or moderate, first-borns typically outperform later-borns (see Altus, 1966, for a review of such findings). The obtained result is, therefore, consistent with previous birth order findings and confirms the assumption that extreme levels of stress were not induced by the TEKTITE environment.

Predictive Equations. Heretofore we have been discussing predictive variables only in isolation. This is inadequate because such variables interact. That is, predictive variables may be correlated with each other to a greater or lesser degree. To obtain maximal effectiveness in the prediction of a behavioral criterion, one must consider the combined effects of the predictive measures employed. This is typically done by using the statistical technique of multiple regression. While a discussion of multiple regression is beyond the scope of this report (see McNemar, 1970 and Cohen, 1968), suffice it to say that multiple regression results in a statistic, the multiple correlation coefficient (R); R squared is the percentage of variance on a criterion measure which is accounted for by a given set of predictors. The multiple regression procedure consists of the calculation of weights for each predictive variable which produce the highest possible correlation between the criterion measure and the group of predictive variables used.

The ability of Life History Questionnaire variables to account for observed variance in behavior was tested by performing multiple regression analyses using the three sets of conceptual variables independently. It must be emphasized that these analyses are preliminary and that the development of final, predictive, test batteries will be undertaken only after extensive cross-validation studies of the LHQ in other populations have been completed. Despite this disclaimer, it can be seen that impressive multiple correlations with the criterion can be obtained using conceptually discrete sets of predictors.

The multiple correlation between nine Environmental LHQ variables and the criterion was .79. Variables were selected from the E pool using the Wherry Test Selection method (Wherry, 1946; Hutchins, 1970). The obtained multiple R means that more than 62% of the criterion variance was accounted for by this group of predictors. The variables used for prediction were: clothing quality, food quantity and quality, family size, height, parental physical affection, parental physical punishment, father's employment, hometown size and size of school. The relative importance of each variable in the predictive equation (its Beta weight) is shown in Table VIII-2.

A second multiple regression was computed using I LHQ variables as predictors. Five I variables formed the equation, again using the Wherry technique. The resultant multiple R was .69, accounting independently for 48% of the criterion variance. The variables used in this prediction were: financial independence, school performance, religious activity, work (during the school year), and work (during summer vacations). The weights for each predictor are shown in Table VIII-2.

The third multiple regression was computed using the Wherry technique with the C pool of LHQ variables reflecting changes during childhood and youth. Five variables produced a multiple R of .54 accounting for 29% of the criterion variance. The variables resulting in this correlation were: changes in quality of clothing, changes in type of residence, changes in health, changes in father's employment and changes in mother's employment. Again, the relative weight of each variable is shown in Table VIII-2.

The crucial point for this discussion is that, using three conceptually independent sets of predictors derived from the LHQ, variables from each set can independently account for a meaningful percentage of the variance recorded on the criterion variable. These results provide considerable evidence that the LHQ is a highly sensitive instrument.

Brief mention should be made of multiple regressions on another criterion measure as an example of the power of the LHQ as a predictor. Because of the strength of group effects on performance (described in Section VI), a separate criterion called Marine Science Deviation was derived for each Scientist-Aquanaut. This measure is computed as the signed difference between the Total Marine Science score of each Scientist-Aquanaut and the mean score of the other four Aquanauts on the same criterion. Using the deviation score for each Aquanaut as a criterion

Table VIII-2

1. Regression of Environmental LHQ Variables on Marine Science

Marine Science Criterion (Scientists only, N = 40)
Multiple R = .79, Shrunken R = .71

LHQ#	Beta Weight	Name
7	-.527	Clothing quality
8	.486	Food quantity and quality
6	-.216	Family size
11	.269	Height
29	.367	Parental physical affection
31	-.336	Parental physical punishment
9	.258	Father's employment
2	-.252	Hometown size
15	.203	Size of school

2. Regression of Individual Motivational LHQ Variables on Marine Science

Marine Science Criterion (Scientists only, N = 40)
Multiple R = .69, Shrunken R = .64

LHQ#	Beta Weight	Name
25	.273	Financial independence
16	-.407	School performance
20	-.252	Religious activity
26	.307	Work (school year)
27	-.179	Work (summer)

3. Regression of LHQ Change Score Variables on Marine Science

Marine Science Criterion (Scientists only, N = 40)
Multiple R = .54, Shrunken R = .436

LHQ#	Beta Weight	Name
7	-.469	Clothing quality changes
4	.266	Type of residence changes
13	.238	Health changes
9	-.258	Father's employment changes
10	.175	Mother's employment changes

allows us to assess the importance of the group as a determinant of performance and to control for its effect. The results again attest the power of the LHQ as a predictor. Using the deviation score for each Aquanaut rather than his absolute Marine Science Score, the variance accounted for by the same LHQ items increases. The multiple R's for each set were: E variables--$R = .80$, $R^2 = .64$; I variables--$R = .74$, $R^2 = .55$; C variables--$R = .59$, $R^2 = .37$. These correlations show that the LHQ can not only predict absolute performance but can also specify the direction and magnitude of deviation from group norms.

Cross-Validation of LHQ Predictors. The results from multiple regression with LHQ variables as predictors are so strong as to raise questions about whether they might be accounted for by peculiarities in the relatively small sample of Scientists employed in the analysis. As a first cross-validation of the instrument, one of us (Radloff) obtained complete LHQ responses from a class of U. S. Navy enlisted men attending 2nd Class Diver's School ($n = 38$). As a criterion measure for the LHQ in this population, we used completion of school defined as 0 = failure, 1 = completion of SCUBA training, 2 = completion of SCUBA and Hard Hat Diving courses, This group provided a difficult test sample for cross-validation. Not only was a highly restricted criterion employed, but the two populations were dramatically different on almost every possible dimension. In addition to the fact that the mean age of the Navy sample was 10 years younger than that of the TEKTITE Aquanauts (21 vs. 31), the two groups differed significantly ($p < .05$) on 16 of the 39 variables derived from the LHQ. To note a few of the major differences between the samples, the TEKTITE Scientists came from larger hometowns, received more parental praise and physical affection, performed better in school, and had more changes in place of residence, type of school, and changes in school performance. The Navy divers received more physical punishment, came from more homogeneous communities, went out at night and dated more, and had more clashes with authority. These differences were predictable and clearly reflect, among other things, social class differences between the two samples.

The cross-validation was conducted by using the same predictors and the same Beta-weights employed in the TEKTITE sample to predict the three-point school completion criterion. The results are extremely encouraging. The multiple R's obtained were: E predictors--$R = .37$; I predictors--$R = .33$; C predictors--$R = .46$. Given the great differences in the nature of the two populations, the fact that the same variables weighted in the same way predict so well in both groups attests to the overwhelming importance of a limited number of demographic variables. Predictors derived through consideration of the requirements of the Navy Diving task and the characteristics of the available population of potential divers should be far more effective in accounting for variance on the school completion criterion. This research needs to be undertaken.

In conclusion, the research conducted during TEKTITE II has provided an opportunity to validate a sophisticated technique of demographic prediction against a highly reliable and objective criterion of behavior. The results obtained indicate that an extremely effective predictive test has been developed which needs only refinement and validation to become generally applicable to both research into antecedents of behavior and selection of candidates for specialized roles. The applications of the LHQ seem almost unlimited; a wealth of data are available; the limitations are in the sampling technique employed and the ingenuity of the researcher.

IX. Conclusions and Recommendations

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The first conclusion which can be drawn from the research conducted on human behavior in TEKTITE is that both male and female Aquanauts can adapt successfully to life in a confined environment such as the habitat. Not only can individuals cope adequately with confinement and isolation, they can also perform work roles effectively in such a setting. The amount of work accomplished by the Aquanauts was great-- probably surpassing the average daily time expenditure of most scientists and engineers in normal, terrestrial environments. Within this overall, excellent work output, there were, however, large team and individual differences and the prediction of this variability forms a major aspect of the research.

The significant difference in performance found between teams probably results in large part from the setting by crews of group norms for behavior in the absence of externally imposed standards. In operational programs (where research on human behavior is not a primary concern) it would seem highly advantageous to communicate realistic performance expectancies to crew members. Such external control should serve significantly to reduce between-crew variability in work output.

Teams on which a Scientist-Aquanaut was leader achieved more Marine Science than those with Engineers as leaders. This was attributed to the fact that the mission role of the Scientist was congruent with program goals while the Engineer's mission role was largely one of support. Thus, the Engineer as leader should not be expected to facilitate performance of the primary mission task-- scientific research. A general recommendation is that, where operationally feasible, mission leaders should be individuals whose professional training is in the area most relevant to project goals. In the case of programs such as TEKTITE, a Marine Scientist should be the most effective leader.

Examination of Engineer-Scientist relations indicates that group relations were better and performance was higher when the Engineer became actively involved in Scientific programs and, concurrently, when Scientist-Aquanauts played a more active role in Habitat Maintenance. Although more investigation of this phenomenon is required, it seems that those selecting crews with mixed professional interests for isolated environments should be concerned with choosing individuals who have broad interests and who are eager both to acquire new knowledge and to impart their own expertise.

Changing Engineers in mid-mission did not have an adverse effect on performance although group cohesiveness and Gregariousness did decrease on addition of a new member. One implication of this finding is that isolated groups can successfully cope with the rotation of one of their members. This must be regarded as a tentative finding since there were only two instances of change and since the Engineer was a peripheral member of the group.

There were strong overall relationships between in-habitat activity variables. The percentage of time spent sleeping was negatively related to performance criteria as was time spent in Leisure. These correlations seem to reflect individual differences in motivation which are predictable. Gregariousness was significantly related to both Total Work and Total Marine Science. Those who spent most time in social interaction achieved higher Work output. Communication with topside personnel was also positively related to performance.

Although we have not yet analyzed specific data on patterns of communication, it appears that the provision of a two-way video link to the surface plays an important role in maintaining good relations between Aquanauts and surface-support personnel. Preliminary analysis of some of the behavioral data by Silverman (1970) suggests these conclusions. The video link seems to reduce feelings of isolation and overt hostility towards remote operational personnel which have been prominent in other, similar environments such as SEALAB (Radloff and Helmreich, 1968). It seems advisable to include two-way video links between remote groups and control centers whenever feasible in future operations.

Detailed analyses of meal behavior data have not yet been undertaken. However, several comments about the effects of the NASA food program may be warranted. Pre-packaged frozen meals were used on all of the long missions and one of the short missions. Although use of the frozen meals (which had only to be heated) did markedly reduce time spent by Aquanauts preparing meals and cleaning up, this time-saving was not reflected in higher Work output. Time gained by using packaged food was used for Leisure rather than Work.

Preliminary analyses of time factors in habitat behavior show significant shifts in activities over time. Aquanauts spent less time working, more time in Leisure, and more time sleeping in the second half of missions than they did in the first half. The changes in behavior were much more dramatic in short missions than they were in long missions. Behavior in long missions was generally more stable than in two-week missions, suggesting that more adaptation to the habitat environment took place in the 20-day period. This stability implies that three-week periods are much better models of long-term confinement than two weeks, and that results from three-week missions may generalize to much longer periods. Extensive analysis of daily patterns of behavior is needed. These analyses should provide much useful information on circadian rhythms and on causal relations between mood and activities and among activity variables such as Leisure, Sleep and Work.

The Life History Questionnaire has proved to be a highly effective predictive instrument. Conceptual variables derived from the LHQ can account for a meaningful percentage of the observed variance on performance variables. When validation and refinement of the LHQ have been completed, it should prove to be an outstanding instrument for both personnel selection and psychological research. Preliminary cross-validation indicates that it can predict performance even in a highly different population.

One of the most important aspects of the study is the validation of the observational methodology. The results show that reliable and meaningful data can be collected from natural groups over time. The techniques employed in TEKTITE should be easily adaptable to a wide assortment of natural situations. One obvious application is to manned spaceflight and spaceflight simulations.

A logical refinement of the methodology will be to convert data management programs developed during TEKTITE for real-time operation. This would make it possible to provide operational personnel with immediate data on reactions and patterns of behavior. This raises the possibility of more effective intervention in group processes to eliminate developing problems and facilitate performance and adjustment.

It is all too typical to end with a call for further research. Although this call could easily be issued for the follow-up of numerous important paths opened by the study, it may be more appropriate to note how much remains to be gleaned from the mass of research already completed. A large archive of highly reliable data on real behavior has been amassed in which researchers can test important theoretical hypotheses for some time. This seems to us quite sufficient to answer those who claim that the "real world" is too difficult and costly an arena for psychological research. If we were to be allowed only one conclusion from our experiences in TEKTITE, it would be this: not only is work in the field possible and rewarding, but also, the quality and breadth of the data collected more than offset the difficulties involved in their collection.

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13. ABSTRACT

The report describes preliminary findings from a large-scale field research project involving continuous, systematic observations of 10 teams of Aquanauts over a period of 182 days. Questions of field methodology are discussed, and the development of an effective new predictive instrument, the Life History Questionnaire is reported.

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